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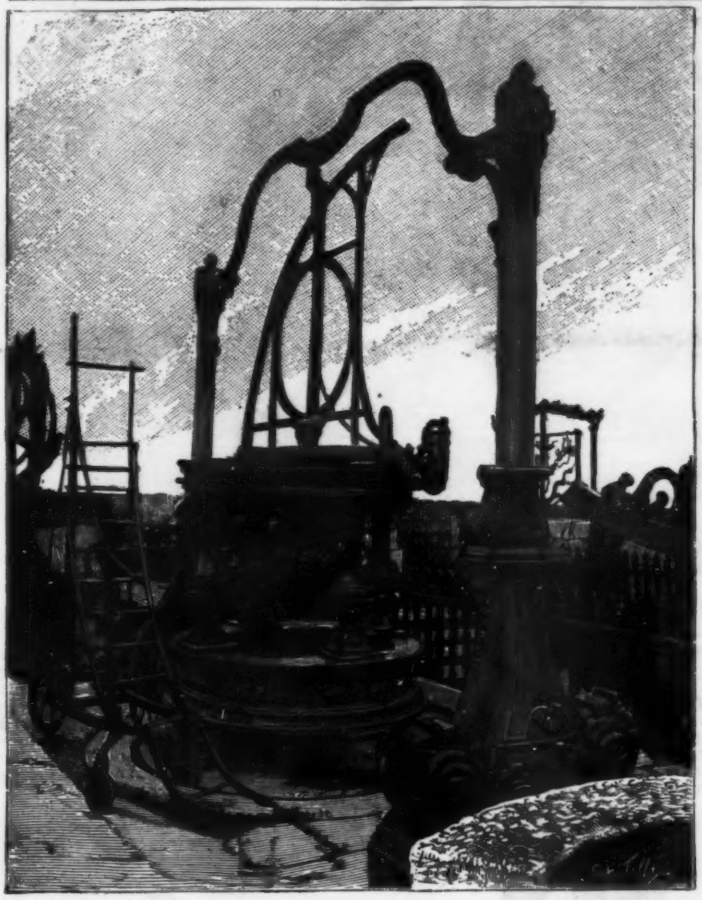


BRONZE QUADRANT SENT BY LOUIS XIV. TO EMPEROR KANG-HI.

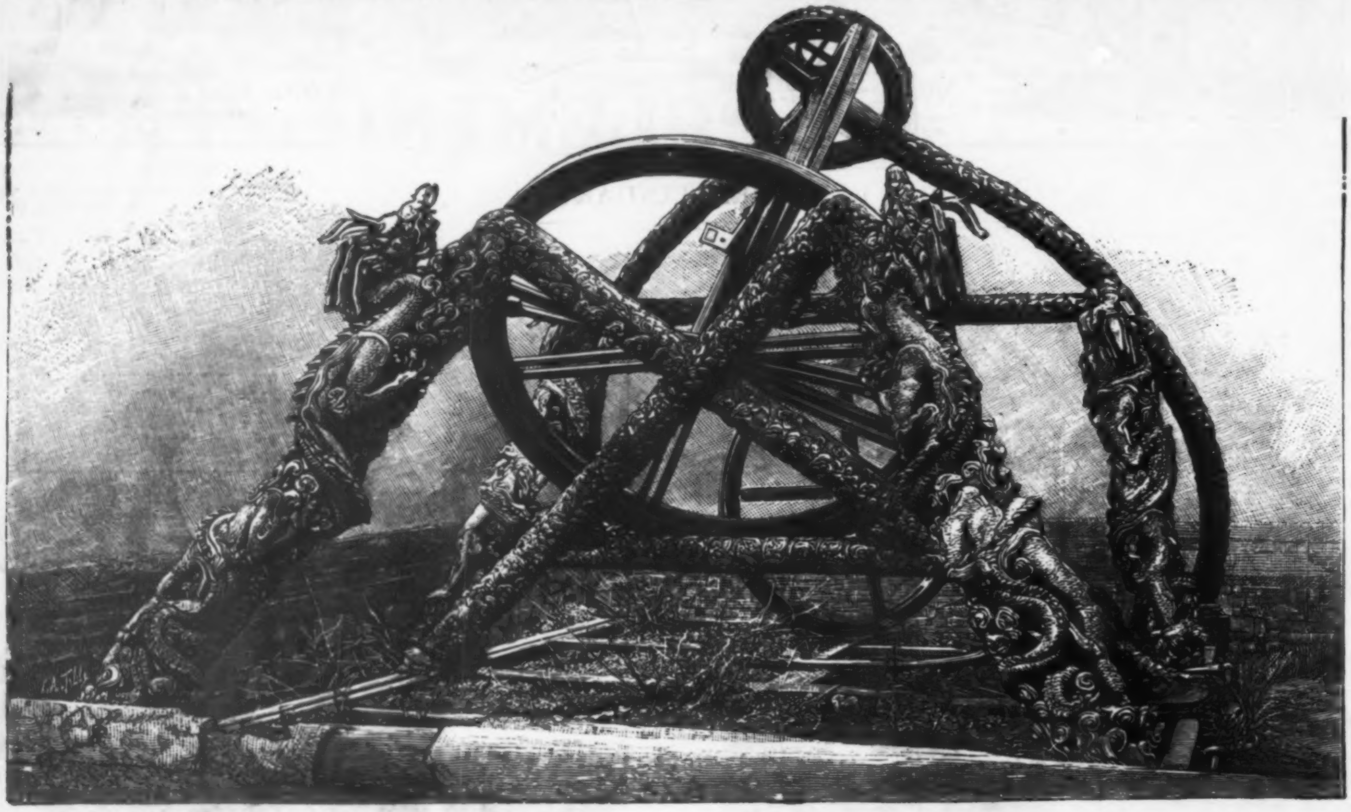
CHINESE BRONZE ARMILLARY SPHERE (SEVENTEENTH CENTURY).

BRONZE CELESTIAL GLOBE (about 7 ft. in diam.) CONSTRUCTED BY PERE VERBIEST, IN 1674, AT THE OBSERVATORY OF PEKIN.—From a photo.

THE PEKIN OBSERVATORY.

THE eminent director of the Paris Observatory, Admiral Mouchez, has just received a very curious collection of photographs of the Pekin Observatory and the principal instruments that are still in use in the capital of the Celestial Kingdom for astronomical study. This collection will be presented to the Academy of Sciences by the Admiral at one of its coming sessions. Thanks to the politeness of Mr. Faissinet, secretary of the director, it has been possible for us to reproduce five of the finest views of the series. Figs. 2 and 3 represent a bronze sphere and a celestial globe of the same material, nearly seven feet in diameter, constructed under the direction of Father Verbiest in the seventeenth century. Fig. 1 represents a bronze quarter-circle sent by Louis XIV. to the Emperor Kang-Hi in the seventeenth century. Fig. 4 represents the chief piece of this observatory, so rich in artistic wonders. It is a bronze astronomical instrument vaguely recalling an equatorial. It was constructed in the thirteenth century by Ko-Chon-King, astronomer of the emperor of the first Tatar dynasty and the founder of Pekin. The fifth engraving gives a general view of the astronomical instruments installed upon the terrace of the observatory by Father Verbiest while he was president of the tribunal of mathematics in 1674. Up to the present, nothing has been changed in the arrangement of these apparatus, and they stand now just as they were placed by the learned missionary two hundred years ago.

The general view of the Pekin Observatory, established at the beginning of the nineteenth century near the Tatar rampart and the Temple of the Lettered, has a feudal character which more closely recalls the old gates with elliptic arches of the fortified cities of the Middle Ages than the original structures of the extreme East. It is a massive square tower, of medium height, at the top of which is observed a series of odd silhouettes. These latter are those of the instruments shown in one of our drawings. A little lower, from the left of the tower, starts a sort of shed with curved roof, and very Chinese, under which have rested, since the foundation of Pekin, a few Mongolian instruments, which are genuine artistic marvels, that our engraving can scarcely give any idea of.



CHINESE BRONZE ASTRONOMICAL INSTRUMENT OF THE THIRTEENTH CENTURY.

GENERAL VIEW OF THE ANCIENT ASTRONOMICAL INSTRUMENTS AT THE CHINESE OBSERVATORY, PEKIN.—From a photograph.

This observatory is one of the rare curiosities of the capital of the Celestial Empire.

According to those who have studied them, the accuracy of the instruments is questionable; the Chinese artisans charged with the graduation not having reproduced with exactness the models given to them.

Nowhere is there met a trace of a telescope or even of a simple tube capable of concentrating the visual rays of the observer upon a single point. The pinnule is alone employed for observations. Fortunately for science, alongside of this official observatory, the Cluny Museum of Chinese astronomy, stand some establishments, such as Lika Wey, in which are found the most improved models of contemporary optics.—*L'Illustration.*

THE ASTRONOMICAL OBSERVATORY AT PEKIN.

ADMIRAL MOUCHEZ has just received from Pekin, for the Museum of Astronomy that he founded at the Paris Observatory, a series of photographs representing, under every aspect, the Pekin Observatory and the instruments installed therein. It is through the kind aid of M. Lemaire, the French ambassador to China, that the Paris Observatory has been enabled to acquire these interesting photographs.

Astronomical functions have not ceased to be an honor in China, and the observatory of the Celestial Empire is now under the direction of an uncle of the emperor, having the rank of fifth prince of the blood and bearing the title of chancellor.

The number of persons attached to this observatory is larger than at Paris, there being no less than 196, including the students. The chief officials, after the chancellor, are a Chinese and a Tatar director having a right to the button of precious stones and bearing upon the breast the image of a sea raven. Then come two sub-directors, one of them Chinese and the other Tatar, and two assistants who have charge of the calculations. These latter, before the expulsion of the Jesuits, always had to be selected from among foreigners. There is also a keeper of the buildings, and a keeper of the water clocks which the astronomers still use, chronometers not having been introduced into the observatory—something that may be said also of telescopes.

The calculators are in possession of tables constructed or rectified by the Jesuits of the 17th century, which they use for making their calculations, and which they preserve closely hidden. It results from this that, contrary to the general principles of the Chinese government, astronomical functions have become hereditary; but, as an offset, they are simply honorary.

Purely scientific functions are not very difficult to exercise, since there are a few private observatories at Pekin even belonging to European legations. Besides, at Zi-Ka-Wei, the missionaries have organized a first-class observatory, in which all the modern methods are practiced with first class instruments. This establishment is situated at about 240 miles to the southwest of Pekin, in the neighborhood of Shanghai. The astronomers of the Chinese government are capable of performing calculations of inversions without much trouble.

But, in addition, they have had to acquit themselves of a more delicate mission in which European scientists cannot aid them, and that is to determine fast and nofast days—an operation of the highest importance in a country where astrological beliefs are universally spread. They are obliged, also, like the ancient soothsayers of the Eternal City, to consult presages, and this they do in a very naive manner.

The council of the Pekin Observatory assembles in a body on the evening of the last day of the year, and remains in session until the beginning of the following year, which is at midnight. At this moment the astronomers observe from which point the wind comes, and interrogate the latter by means of several banners arranged for the purpose. On the 14th of February, 1888, at the beginning of the 25th year of the 67th cycle, which is not yet finished, they found that the wind was blowing from the northwest, a point considered a most favorable augury. From this they drew the conclusion that every kind of happiness ought to be expected during the twelve following months.

The establishment is placed upon a terrace a few yards in height and of square form, situated along the fortifications of Pekin. This structure is traversed by a tunnel through which the road passes, and, if need were, it might be utilized for the defense of the city. Father Lecomte, who had an opportunity of operating the instruments of this observatory in the 17th century, says that the natives who constructed them were more concerned about the perfection of the instruments representing dragons with flames issuing from their snout than about the accuracy of the divisions. He thinks that a quarter-circle of a foot and a half constructed at Paris by the opticians of his time would give a more serious guarantee than the great six-foot circle constructed at Pekin. The limb is divided into tens of minutes, a limit of exactitude to which it might be possible to pretend were the dividing well done, and were the instruments provided with pinnules, which have disappeared.

Father Lecomte describes, also, the installation of a quarter-circle of very careful construction, and which is very probably the one that Louis XIV. sent to his brother king Kang-Hi.

The bob that marks its vertical position weighs a pound and hangs from the center through a fine copper wire. The alidade is marble and runs easily upon the limb. A dragon surrounded by clouds grasps the bands of the instrument and prevents them from getting out of their common plane. The entire quarter-circle is in the air, and is traversed through the center by an immovable axis around which it revolves toward the parts of the sky that it is desired to observe.

There is also upon the observatory terrace an armillary sphere, as well as an equinoctial sphere and a celestial one six feet in diameter. The latter excited the admiration of Father Lecomte. It is, in fact, very remarkable, because all the stars are in their exact position and are represented in relief. It was so well suspended that a child could turn it in the direction of the diurnal motion, although it weighed 2,000 pounds.

Father Lecomte gives an enthusiastic description of the ornaments and of the hidden wheels that permit of giving the axis of the world the desired inclination. He speaks also of the marble steps by means of which the observer can post himself properly.

One of the most remarkable instruments of the observatory is a gnomon analogous to that used by Kou-Shou-King, astronomer of the Emperor Kublai Khan (founder of the first Tatar dynasty and creator of the city of Pekin), for making the observations spoken of by Laplace in his Celestial Mechanics, and which he describes in these words:

This great observer had instruments constructed that were much more accurate than those that had been used until then. The most valuable of all was a gnomon of forty Chinese feet terminated by a vertical copper plate and containing an aperture of the diameter of a needle. Up to his time, there had been observed only the upper edge of the diameter, and it was difficult to distinguish the term of the shadow, moreover, nothing but the eight foot gnomon, five times shorter, had been used. The observations made from 720 to 1280 are valuable for their accuracy. They incontestably prove the diminution of the obliquity of the plane of the ecliptic and of the eccentricity of the terrestrial orbit from that epoch to our day.

Besides the instruments just mentioned, there is a very ancient armillary sphere which dates from the 13th century. The bronze dragons which support it are remarkable and very artistic. The instrument is a true art object.

Father Verbiest transformed the observatory in 1670, nearly at the epoch at which Dominique Cassini was founding the Observatory of Paris at the order of Louis XIV. He had the instruments of Kou-Shou-King, most of which still remain, removed to another place. It may be seen from their form that they scarcely differ from those of Father Verbiest except in a greater profusion of ornaments and in being more difficult to maneuver. They are divided into 365°, so that the sun describes exactly one of these divisions per day. It is well to add that they are like those that Tycho had constructed at his observatory of the Isle of Huen and with which he made observations at the end of the 16th century, that is to say, three centuries after. It may even be added that they differ from the instruments of the present only in the substitution in the latter of telescopes for pinnules. The Chinese had no use for telescopes, for, in fact, their minds never felt the need of sounding the mysteries of the infinite that surrounds us on every side. For them, astronomy had no value except that it gave them a means of celebrating at the proper time the idolatrous feasts that take place at a fixed epoch in the various temples in which the emperor executes the sacrifices imposed by the sacred books.

The needs of pure abstract science did not exist for them. The great philosophical revolution of which Copernicus gave the signal, and Galileo accomplished, in no wise excited them. The majority still believe that the earth is the immovable center of the world, and the telescopes that would oblige them to admit the contrary have not as yet acquired the "freedom of the city" in their astronomy. Such, probably, is the secret of this singular arrest of development among an ingenious people which has given astronomy its first scientific development. In fact, it may be said that the history of Chinese astronomy begins with that of the Chinese empire, and that the ideas of harmony that the spectacle of the celestial vault awakens were the very basis of its institutions.

It is certainly superfluous to dwell upon the instruction that such a decadence should give us and upon the consequences of scientific philosophy that it is indispensable to draw from it.

Let us add that Father Verbiest, second founder of the Pekin Observatory, died in that city in 1688, just two hundred years ago.—*La Nature.*

EXPLOSION OF A MOUNTAIN IN JAPAN.

A FEARFUL catastrophe, and one perhaps unique in the history of geology, occurred in Japan on the 15th of July of the past year. An entire mountain (Mount Bandai) was thrown into space, after the manner of the explosion of a gigantic boiler, through the expansive force of steam generated in the depths of the earth. Villages were engulfed, about five hundred inhabitants were killed, torrents of mud inundated the neighboring regions, and showers of hot dust covered the surface of immense territories. As soon as the news of this catastrophe became known, the Japanese government sent a delegation to the spot to study the exceptional phenomenon. Among the members of this was Mr. W. K. Burton, of the University of Tokio, who has published a long report upon his expedition, during the course of which he took a certain number of photographs.

FIG. 1.—ERUPTION OF STEAM FROM THE CRATER IN MT. BANDAI.

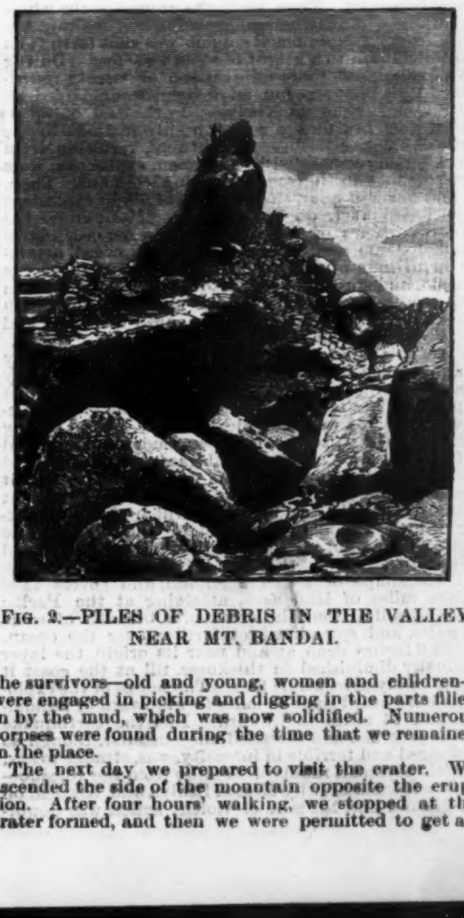


FIG. 2.—PILES OF DEBRIS IN THE VALLEY NEAR MT. BANDAI.

The theater of the eruption was Mount Bandai, which is situated to the north of Lake Inawashiro, one hundred and fifty miles north of Tokio. Before the catastrophe, it was a mountain with three peaks, about 4,800 ft. in height. According to the survivors of the catastrophe, it is impossible to describe with accuracy what occurred at the end of the terrible day of the 15th of July. Terrible earthquakes occurred amid the noise of detonations compared with which all the pieces of artillery in the world thundering at once would give but a feeble idea. The air was absolutely darkened by thick clouds of black dust, and here and there blocks of stone and enormous masses were projected in the midst of a furious wind. Here torrents of mud were flowing, and there hot dust was falling from the sky. Darkness was absolute, and entire nature seemed to be submitted to a final upheaval. After a careful examination of the regions devastated, Mr. Burton found that the eruption had not been volcanic in the usual acceptation of the word. There was absolutely no trace of fire or lava anywhere. The phenomenon consisted in an explosion due to the expansion of steam. It would be impossible to estimate what a formidable pressure it required to displace a mountain. Streams of hot water had been escaping from the sides of the mountain from time immemorial, and this indicated that the subsoil was at a very high temperature. The explosion projected into space the whole median part of the mountain, including the central peak. The projection was not vertical, but inclined, so that the debris fell back at the side, burying the valleys and covering a large extent of country, estimated to be of an area of about 14,000 acres. The thickness of the debris with which the ground was covered varies from ten to one hundred feet, and, exceptionally, in certain places, it reaches nine hundred feet. A remarkable fact is the heaping up of these debris. The darkness that accompanied the cataclysm was certainly produced by the huge quantity of dust dispersed in the atmosphere in thick clouds under the action of the steam. The dust covered the entire country in the direction of the prevailing wind, and the darkening of the sky lasted for several hours. In certain places the dust falling from the air was so hot that a person could not touch it without being burned, and it is probable that, among the victims of the catastrophe, there were some who were smothered by it.

FIG. 3.—SECTION OF MT. BANDAI.

(The light portion is the part projected into space.)

The eruption was accompanied with torrents of mud that spread through the valleys as far as to nine miles distance from the crater. These torrents swept everything in their passage and they filled up a river at a certain place. A lake formed behind the obstruction.

After giving this general account, Mr. Burton tells about his exploration on the very scene of the catastrophe.

We reached, says he, the village existing nearest the crater. This village was half buried beneath a river of mud, the other half was intact. When we arrived, the survivors—old and young, women and children—were engaged in picking and digging in the parts filled in by the mud, which was now solidified. Numerous corpses were found during the time that we remained in the place.

The next day we prepared to visit the crater. We ascended the side of the mountain opposite the eruption. After four hours' walking, we stopped at the crater formed, and then we were permitted to get an

exact idea of the nature of the phenomenon. We were upon the edge of an immense chasm which had previously been the mountain. This chasm lay open opposite to us, and formed a huge excavation, whose sides increased from 90 to 1,200 feet in height. From the bottom of the abyss there were still to be seen escaping torrents of steam that formed true clouds. In the distance was perceived a devastated country. All had been transformed into a desert consisting of a chaos of piled-up debris. Nothing could give an idea of the horror of the scene.

The travelers descended to the place whence the steam was escaping under a high pressure from fissures in the rocks. It rose to the highest regions of the atmosphere and became confused with the clouds. Mr. Burton took several photographs of the phenomenon, and one of these, showing one of the most important eruptions of the steam, is reproduced in Fig. 1.

After these operations, Mr. Burton and his companions traversed the devastated regions. A large number of villages were absolutely overturned by the tempestuous wind produced at the moment of the eruption.

The third day of the exploration was devoted to traversing the regions covered with the debris of the mountain. Fig. 2 gives the aspect of one of these heaps.

Fig. 3 is a diagram sketched by the explorer. It represents the state of Mount Bandai before and after the catastrophe.

The explorer states that he could not resist a great emotion and unforgettable feeling of sadness on thinking that, under the rocks and blocks of heaped-up earth which he was walking over, there were entire villages forever buried with their numerous inhabitants.—*La Nature.*

THE SHO-BANDAI-SAN ERUPTION.

NEXT to the Krakatoa eruption, on August 26 and 27, 1883, the eruption which destroyed the peak of Sho-Bandai-san, Japan, on July 15 last, will rank as the most gigantic and most disastrous upheaval of modern times. Partial accounts of the eruption have already been published, but they all fail to give that explanation of the phenomenon which patient and scientific investigation on the scene of the disaster alone could afford. That explanation has now been furnished, and is contained in the report of two highly trained Japanese specialists, Professor Sekiya, a young seismologist already well known, and Mr. Y. Kikuchi, a geologist—both of the Imperial University, Tokio. The two scientists have embodied the results of their investigations, or as much of them as we are ever likely to know of volcanic manifestations of the first order, in their report, which is given in the form of a paper read before the Seismological Society of Japan on October 11. As they carried on their investigations under highly favorable circumstances, their paper, for which we are indebted to the Tokio correspondent of the London *Times*, is full of interest for the student of natural science.

Sho-Bandai-san, the peak that was destroyed on July 15, is, or was, one of a group of four conical mountains, known collectively as Bandai-san, forming the walls of an old elevated crater basin, and rising to a height of some 6,000 feet above the sea. Stratified volcanic rocks, of the most part gneiss and andesite, constitute the bulk of this mountain mass, and are mainly disposed in six great layers, the fruits of as many successive eruptions. Lava, apparently of prehistoric date, is found on the slopes. But, though Japanese records often speak of fire and smoke and poisonous vapors issuing from Bandai-san, the latest known active eruption took place 1,081 years ago, and all that remained to warrant the mountain's retention in the list of live volcanoes were a few solfatara in and near the old crater, Numanotaira, which from time immemorial have given off steam. On the morning of July 15, however, this condition of tranquillity was suddenly and violently disturbed. Soon after the mild preliminary earthquake, which took place at about half-past seven, there came a second and prolonged shock of fearful intensity. Then, while the ground in the whole region was still heaving and groaning and making the houses rock, a dense black column was shot forth from Sho-Bandai-san to a height of some 4,000 feet. During the next minute there were fifteen or twenty repetitions of this phenomenon, all of them accompanied by horrible and tremendous noises. In the last of them, the ejectamenta took a course highly inclined to the vertical. Zigzag flashes of lightning, resulting from the electricity generated by the steam explosions, were seen to shoot forth from ascending columns. Then, for another half hour, the thunders of minor explosions were heard at frequent intervals. Meanwhile, the lighter particles of the black columns, consisting of mingled steam and dust, rose steadily upward, attaining an altitude of some 12,000 or 15,000 feet above the volcano, and spreading out into a vast cloud like an open umbrella in shape, which shrouded the earth beneath it in midnight darkness, until dispersed and wafted away by the northwesterly wind.

From this cloud descended the shower of blue gray ash, so called, which has been mentioned in every account of the catastrophe—in reality, volcanic dust or powder (augite-andesite), caused by the violent mechanical disintegration of ejected rocks, hurled swiftly through the air after having been rendered brittle and soft by the action of steam and gases. Highly heated itself, and mingling with the condensing steam, it assumed a fine granular shape, and fell on the adjacent country in a solid, scalding rain, which caused shocking injuries to many individuals, and clothed the ground with a hot mantle on which it was difficult and painful to walk. On the map, this dust-strewn region has the shape of a half open fan, and covers 1,040 square miles of land area, attaining at the Pacific shore, 62 miles from the volcano, a breadth of some 41 miles, and spreading yet farther over the ocean. About 6 inches deep at and near its origin, the layer gradually diminished in thickness, till at the coast it was a barely perceptible film. The noises of the explosions were heard some 30 miles to windward of Bandai-san and 62 miles to leeward. But the earthquake which preceded and attended the outburst, though so prolonged and terrible in intensity, was, strange to say, not felt beyond a radius of 30 miles from the volcano—a fact accounted for by Messrs. Sekiya and Kikuchi on the ground that the seat of violent action was doubtless but a little way below the earth's surface, if, indeed, not above the mean periphery and in the bowels of the mountain itself. Steam—a well-known and powerful cause of seismic phenomena—was, as has been already indicated, the agent of the explosions. The great volumes of steam that must be generated whenever, from any cause, subterranean waters are brought into contact with the molten interior, expand and fill up the rock fissures. If not deep enough down, or if lacking sufficient pressure and volume to break through the superincumbent masses, such ebullitions, though they may wrench and strain and tear the earth's crust internally, are yet hopelessly imprisoned and can only produce on the surface the phenomena of earthquakes or minor seismic vibrations. But there are cases—happily none too common in this our day—when the pent-up vapor succeeds in bursting open its prison roof along some line of least resistance and working havoc on a prodigious scale. Of such was the explosion which lately rent Sho-Bandai-san in twain.

Besides the lighter erupted matter, the nature and behavior of which have been sketched above, there was the solid body of the peak itself, which, tossed in gigantic masses high into the air, fell upon the slopes and glens, and, rushing down them with fearful velocity until brought to rest on level ground or by impassable obstacles, buried 27 square miles of country fathoms deep in debris in the short space of about ten minutes from the first explosion. One of the toughest of the many problems which beset the Japanese investigators was that of accounting for the wonderful and apparently eccentric fashion in which this mighty volume of matter had been propagated and disposed. Persevering examinations, however, soon brought them to intelligent conclusions; and these were confirmed before the very eyes of Professor Sekiya by an occurrence which, though doubtless gratifying to that ardent seismologist, was not, as he dryly remarked, a particularly comfortable incident of a solitary ramble. One day, while he was at work in the crater, a huge slice of the precipitous rear wall that had been bared by the explosions fell of a sudden, quite near to, but happily clear of, him, and crashed with a tremendous uproar down the steep mountain side. This slab was about 1,000 feet high and of considerable thickness. He witnessed its fall and its long descent. He saw how the great masses of earth and rock were shattered as they fell, and broken up into bits ever growing smaller as the velocity and the distance increased, and as the fragments were dashed against one another and against obstacles in their way, until they finally lost cohesion, and were reduced to a pulverized, almost impalpable, state, not very different from that of sand. The behavior of the mass now resembled the rush of a headlong torrent. Tough bowlders able to survive the ordeal were of course mixed with the finer matter, and great rock masses from 20 to 30 feet in diameter were floated down on the surface. But, as a whole, the movement approximated to that of a fluid. No words, says the Professor, can describe the "fierceness and force" of that magnificent and impetuous downpour—its mad surgings this way and that, and the bold leaps with which it would now and then bound over low hills that hindered its progress, and shoot onward down the neighboring depression. Similar, though on a vastly greater scale, must have been the awful avalanches which darted down from Sho-Bandai-san in two principal streams on the fatal morning of July 15. These, it is now known, dashed over hills and ridges fully 100 feet in height, and Professor Sekiya's estimate that they must have attained a velocity of nearly 50 miles an hour sufficiently accounts for the swiftness of the fate that befell the doomed peasantry in the uplands and valleys below. A part, doubtless, of the descending matter, mingling with the waters of ponds and lakes in its course, became a kind of mud, and may have been thus assisted in its flow; while that which reached the Nagase River and swallowed up so many of the Nagasaka villages acquired the consistency of a paste. But by far the greater volume was never moistened, and must have derived its fluid or semi-fluid properties from a rapid process of pulverization after the manner witnessed by Professor Sekiya.

As for the crater, the researches conducted by the Japanese explorers now assign to the disrupted matter dimensions far in excess of all previous estimates. In form, the crater bed is roughly that of a horseshoe, opening northward, and inclined slightly down from the apex to the mouth, where it is nearly 1·5 mile wide. Its whole area is about 950 acres. Round the crown of the shoe is a nearly vertical wall, 1,660 feet high, in front of which everything has been blown away. But the peak itself, which was 540 feet higher than the summit of the crown, lay within the now empty space. Thus the three greatest dimensions of this gigantic projectile were, respectively, about 2,200, 7,500, and 7,800 feet. From these and other particulars it has been possible to estimate very approximately both the volume and weight of the disrupted matter. No fewer than 1,587 millions of cubic yards, weighing 2,880 millions of tons, and spread over 27 square miles of country to an average depth of 57 feet, are the approximate figures with which to estimate the power exerted in this latest manifestation of plutonic energy. A great fissure, doubtless corresponding with the original line of least resistance, runs through the crater from its vertex nearly to its mouth. It is marked by a long range of steam jets, large and small, which puff and hiss forth immense volumes of white pungent vapors. But Bandai-san is now perfectly at rest. Delicate tromometers fail to detect the faintest throb upon its surface. Only that row of jets remains to tell of the fever that rages far beneath.

The terrible blasts of air that accompanied the explosions, and wrought such havoc in the forests and villages, were, of course, corresponding phenomena to those which break windows and lay low the grass and plants at the firing of ordnance. The difference was one of degree only, though some idea of its vastness may be gathered from the fact that in this case villages many miles from the scene were literally wrecked, while in the forests near the crater hundreds of trees three or four feet in diameter were laid prostrate on the ground. Suddenness, from first to last, characterized the whole of this remarkable phenomenon. There had been slight shocks of earthquake on July 8, 9, 10, and 13; also a momentary spasm at about seven o'clock on the morning of the eruption, so feeble, however, that many persons failed to notice it. Strange rumblings, taken for distant thunder, were heard in the mountains soon after seven. But of palpable warning there was virtually none, with, perhaps, the bare exception that animals in the neighborhood are said to have shown signs of uneasiness and fear shortly before the outburst. It is a well established fact that animals are highly susceptible to minute tremors of the ground, and as the earth in the vicinity must have been more or less affected before such an explosion as that of Bandai-san took place, it is quite conceivable that there may have been a succession of microseisms perceptible only to the delicate senses of the quadrupeds and other dumb creatures. Well waters are said to have diminished in some places before the eruption occurred. But neither before nor after did the large Lake Inawashiro, to the south of the volcano, give any sign of being affected by it. And, generally, it must be owned that the Bandai-san catastrophe and the phenomena preceding it have not brought us any nearer than we were before to the power of saying when—or even where—volcanic mountains may be expected to give vent to their hidden fury.

[NEW YORK SUN.]

HOW THE WORLD APPEARS TO THE LOWER ANIMALS.

SIR JOHN LUBBOCK, in the last volume of the "International Scientific Series," *On the Senses, Instincts, and Intelligence of Animals, with Special Reference to Insects* (D. Appleton & Co.), says: "It has always been to my mind one of the most interesting problems of natural history to consider in what manner external objects affect other animals, how far their perceptions resemble ours, and whether they have sensations which we do not possess."

In his investigations into these questions, Sir John has accumulated, partly by his own independent observations and partly by collecting and collating the detached papers of his brother naturalists, an immense number of curious and interesting facts, which are presented to the public in the volume before us. In many cases the conclusions which he reaches will be novel, and even surprising, to the reader who has not followed the course of scientific inquiry in these directions.

Take, for instance, the most highly differentiated of all our senses—that of sight. We are prone to regard our own as the accepted method of seeing, but, in truth, the variations in visual apparatus are almost innumerable. Light affects the tissues of plants and of many of the lower animals in a marked manner, and there are myriads of beings whose only knowledge of light and darkness is gained through the sensitive surface of their whole enveloping tissue. Even some animals as high in the scale of existence as earthworms are without eyes, and yet so curiously sensitive is their whole skin that Mr. Darwin observed that an earthworm, when lying on the surface of the ground, would, if suddenly illuminated, "dash like a rabbit into its burrow." Experiments made with newts, whose eyes had been impenetrably darkened, as well as with some myriapods, show that in these creatures also the entire integument is sensitive to light.

But the first trace of a specialized organ for the perception of light rays is to be found among forms of life much lower than these, and at the very bottom of the scale appear some microscopic organisms belonging to the vegetable kingdom, on which is developed a tiny red spot that is particularly sensitive to such impressions. Sir John presents diagrams to show how an almost complete series of visual organs may be traced from such a spot of color on the surface of the skin up to a true eye. An increase of sensitiveness to luminous stimulants in some special part of the body, a gain in the number and complexity of nerves supplying this spot, and the development of some of the component parts of an ordinary eye, resulting in a dim vision scarcely one degree better than blindness, are the first steps in a gradation at the other end of which are the exquisitely complicated optical apparatus of the higher animals.

Earthworms, as we have said, are eyeless, but worms in general are furnished with eyes of some kind, though these are of such great simplicity as probably to perceive nothing more than the difference between light and darkness. It is well known that insects are often endowed with two sets of eyes, constructed on entirely different principles; the compound eyes, large and bulging, which are such prominent objects on an insect's head, and the ocelli, also situated on the head, but so small as to escape an untrained observer. The compound eyes are formed of many very small facets, each provided with its own nervous appendage, and each, apparently, presenting to the brain its own infinitesimal image of the object before it. If this view of their function be correct, the dragon fly, for instance, who has in each eye about 20,000 such facets, must see 40,000 images of every object within his field of vision. It has been suggested that such a creature is aware of a picture composed, like a mosaic, of a multitude of tiny parts, but, in truth, it would be a difficult matter to arrive at any trustworthy conclusion as to the exact sensation produced in the insect by organs of vision so different from our own. The ocellus, on the other hand, presents but a single image to the brain, and is constructed on a plan somewhat similar to that of the human eye, though differing from it in many important respects. The exact purpose of the ocellus is unknown, though modern naturalists rather incline to the belief that it is employed for near vision and when the supply of light is small.

Why insects should be supplied with such diverse means of seeing it is impossible to say, but they are by no means the only animals who have, or rather who have had, two entirely different kinds of eyes. In the glowworm and in many lizards there exists on the very top of the head an eye formed after the type of those of the invertebrates, and therefore differing altogether in structure from the two ordinary eyes possessed by the same animal. In none of the creatures so far examined has this organ been in a state of functional activity, but it is nevertheless fully established that it is the relic and representative, more or less degraded, of a true seeing eye. Further, from the size of the corresponding orifice in the skulls of the gigantic reptiles of past ages, it is apparent that this eye was much more highly developed among them than among their descendants.

In extant fish and amphibia the organ is still present, though in a yet more rudimentary form; in birds it

also exists, but in them it has lost all semblance of its original nature, and is solid and replete with blood vessels. But, most curious of all, there is in the brain of man himself a small organ about the size of a hazel nut, called the pineal gland, the function of which has always been a puzzle to physiologists, and which was supposed by Descartes to be the seat of the soul. Comparative anatomy has shown that this gland is probably the last trace in man of the same organ, inherited from some remote ancestor of the vertebrates, in whom it was developed into a true eye.

There exists a certain connection between the power of seeing and the capacity for producing light possessed by some animals. Sir John, however, devotes no attention to the manifestation of this latter power among insects, where it is best known, but notices only some of the more curious phenomena regarding fishes. There are present on some fishes curious eye-like bodies more or less connected with the muciferous canal, and though the original opinion that they were accessory eyes is still entertained by some naturalists, yet later researches would seem to show that, whatever other uses they may have, they are certainly luminous organs, and are especially developed in deep sea fishes. The fishes which live in the depths of the sea are comparatively unknown, as they only ascend to the surface of the ocean by some rare accident, and even then the change from the great density of the water in which they are accustomed to live to our upper air to a great extent destroys their tissues.

On this account it is difficult to determine their real characteristics, and our knowledge of them is mainly confined to the few specimens brought up by the dredge, and particularly those obtained by the Challenger expedition. The light of the sun penetrates the ocean only to the depth of 200 fathoms, and below this the darkness is complete. Hence, in many of these deep sea fishes the eyes have altogether disappeared. But others, in which they are still well developed, are endowed in addition with organs capable of shedding light, and evidently under the control of the animal. As a rule, the coloring of these fishes is pink, silvery, or black relieved by dashes of scarlet, and the effect of an irradiation by the sudden flashing out of a light must be very striking. The largest of these luminous organs yet discovered is directly under the eye of the fish, so that the animal is, as it were, provided with a bull's-eye lantern. Others have a pair of similar very large organs in the tail, and still others have developed them at the end of long filaments springing from the head.

With regard to the production and perception of sound among the lower animals, we are told that neither the protozoa nor cœlenterata and very few of the mollusca are known to produce sound. There is one genus of crab which can make a harsh, jarring noise by rubbing a sort of file or rasp on its claw against a ridge on the limb, and some of the lobsters can do the same by rubbing one part of the antennæ against another, but the power of producing sound among the crustaceans, curiously enough, seems entirely disproportionate to the development of their hearing apparatus, which is quite elaborate. We are all well acquainted with the sounds produced by many insects, such as crickets, grasshoppers, katydids, etc., and these sounds are made in various ways, by the wings or by the breathing tubes, which in insects are distributed along the sides of the body, or by rubbing one part of the body against another. In many cases the power of making sounds is confined to the male. A house fly hums on F, and to do so vibrates its wings 21,120 times in a minute, and the bee, which hums on A, moves them 26,400 times in a minute, while a tired bee, which hums on E sharp, vibrates its wings only 19,800 times a minute. Except for these slight changes, due solely to fatigue, the sounds produced by the wings of each variety of insect are unalterable, but those emitted by the spiracles or breathing tubes seem to be more or less under the control of the will, and in this respect resemble what we call a voice. One insect, the cockchafer, not only hums with its wings, but also produces a sound which is peculiarly voice-like, as right behind the opening to each breathing tube there is a horny process something like a tongue, which is made to vibrate by respiration, and thus emit a humming noise.

The auditory organs among the lower animals are situated in various parts of the body, and range through many degrees of complexity, from an apparatus so simple that it is doubtful whether it is intended to receive an impression of sound or simply to record movements of the water, to quite elaborate structures plentifully supplied with nerves. Among the higher crustaceans the auditory sac is usually at the base of the small antennæ, though in one of the lower forms the two ears are situated in the tail. Strychnine is known to increase the reflex power of the nerve centers, and one naturalist took advantage of this to prove that crustaceans are really possessed of a sense of hearing, by placing some shrimps in sea water containing strychnine, under which treatment the shrimps exhibited an extreme sensitiveness to the slightest noises.

It has been demonstrated by numerous experiments that, in some insects at any rate, the organs of hearing are situated in the antennæ, but other observations have seemed to point to a different conclusion, and the highest authorities differ on the subject. The inference from the various recorded observations seems to be that the sense of hearing is not always confined to one spot, and that while in some insects it resides in the antennæ alone, in others it is also situated in other parts of the body. In grasshoppers, for instance, two oval, drum-like structures in the legs have been proved to be auditory apparatus. In true locusts the organ of hearing is situated in the first segment of the abdomen. These, as is well known, have but one pair of wings, in place of the two possessed by other insects, the hind wings being represented by two curious little club-like processes. Yet these minute organs receive the largest nerve in the whole body of the fly, with the one exception of that which supplies the eyes, and are of the most complicated nature. Special sense organs occur also in the wings of other insects, and there is much reason for regarding all of these curious structures as organs of hearing, though many naturalists are opposed to this view, and the question is still unsettled. That in the same creature there should be various organs of hearing, constructed on different principles and situated in different parts of the body, is certainly a curious result of modern research, but it is quite in accordance with the well known tendency in insect organizations to the repetition of similar parts.

The seat of the sense of smell in the lower animals is still very uncertain. In some of the lowest organisms it is probable that no such sense exists. In insects there is good reason for supposing that the sense of smell resides partly in the antennæ and partly in the palpi, and there are some facts which would appear to indicate that the antennæ may be sensitive to certain odors and the palpi to others.

Though it is in every way probable that a sense of taste, to assist them in the selection of their food, is possessed by mollusks, annelids, and other lower animals, yet little or nothing is known as to the organs which exercise this function. Jelly fish, for instance, are quickly affected by any change in the medium which they inhabit, and sink below as soon as it begins to rain, but it is impossible to say what sense it is which is affected. Insects evidently possess a sense of taste; ants have begun to feed on honey mixed with strychnine or alum, and rejected the food as soon as they discovered its hidden flavor, rubbing their mouth parts assiduously to remove the taste. Quinine or glycerine, mixed in honey, they also rejected, but it was evidently on account of the taste, and not from any instinctive apprehension of the injurious results, for Torel found that ants could not detect a mixture of phosphorus with their honey and swallowed it without suspicion, though they became very ill from the after effects. Certain minute pits, furnished with delicate hairs, and found on the tongue and maxillæ of all insects, are probably the organs of taste.

Among the lower animals the outer skin is often very sensitive, and though the minute anatomy of their organs of feeling is still undetermined, yet it is known that sensation is conveyed to the animal by means of nerve fibrils connecting with hairs, bristles, or ciliæ.

All the senses of which we have spoken correspond more or less to those possessed by man, but among the lower groups of the animal kingdom there are various organs, evidently sensory, but the functions of which naturalists have so far been unable to discover. These are often of considerable complexity, more or less fully furnished with nerves, and evidently of great importance to the creature. The immensely diversified bristles and cirrhi of many worms, the curiously formed appendages of the skin on many insects, the whole series of organs contained in the skins of fishes, particularly those connected with the muciferous canal, the singular groups of hairs on some jelly fish, the bright spots around the margin of certain sea anemones, are all evidently the seat of special senses, of the nature of which we are still ignorant. The antennæ of insects, too, are not only the seat of the three senses, hearing, feeling, and smell, but it appears probable from the singular variety of organs with which they are furnished that they perform still other functions. Sir John says: "Some of these antennæ organs, though obviously organs of sense, seem to have no special adaptation to any sense of which we are cognizant."

It is now a number of years since the author announced his conclusion, fortified by many ingenious experiments, that even with regard to those senses which we have in common there is a marked difference, but always to our advantage, between the powers of insects and our own. It appears that with regard to sound some of the lower animals are apparently capable of receiving impressions of which we can have no knowledge. Ants, for instance, make no noise audible to us, yet they have rasp-like organs, similar to those which in larger insects we know to produce sound, and they have also, according to the observations of the author, an auditory apparatus in the legs, similar to that of the orthoptera. Some experiments made with beetles, ants, bees, and wasps showed that while they took no notice whatever of ordinary noises, an imitation of their own sounds made with a quill and fine file immediately excited their attention. "From the fact," says our author, "that the power of producing sounds audible to us is scattered among so many groups, and that the sounds themselves are often so shrill, I am disposed to suspect that many insects usually regarded as dumb really produce sounds, which, however, are beyond our range of hearing."

Sir John also relates again the interesting experiments made by him some time ago to prove that some animals possess the ability to distinguish colors invisible to human eyes. He showed that ants were extremely sensitive to rays of light whose vibrations were too rapid for us to perceive. Experiments made on some small fresh water crustaceans, belonging to the genus Daphnia, seem to show that these also perceive the ultra-violet rays to which we are blind. In concluding his remarks on these subjects, Sir John says:

"It has been shown that animals hear sounds which are beyond the range of our hearing, and that they can perceive the ultra-violet rays, which are invisible to our eyes.

"Now, as every ray of light which we can perceive at all appears to us as a distinct color, it becomes probable that these ultra-violet rays must make themselves apparent to the ants as a distinct and separate color (of which we can form no idea), but as different from the rest as red is from yellow or green from violet. The question also arises whether white light to these insects would differ from our white light in containing this additional color. At any rate, as few of the colors in nature are pure, but almost all arise from the combination of rays of different wave lengths, and as in such cases the visible resultant would be composed not only of the rays we see, but of these and the ultra-violet, it would appear that the color of objects and the general aspect of nature must present to animals a very different appearance from what it does to us.

"These considerations cannot but raise the reflection how different the world may—I was going to say must—appear to other animals from what it does to us. Sound is the sensation produced on us when the vibrations of the air strike on the drum of our ear. When they are few, the sound is deep; as they increase in number it becomes shriller and shriller; but when they reach 40,000 in a second they cease to be audible. Light is the effect produced on us when waves of light strike on the eye. When 400 millions of millions of vibrations of either strike the retina in a second, they produce red, and, as the number increases, the color passes into orange, then yellow, green, blue, and violet. But between 40,000 vibrations in a second and 400 millions of millions we have no organ of sense capable of receiving the impression. Yet between these limits any number of sensations may exist. We have five senses, and sometimes fancy that no others are possible. But it is obvious that we cannot measure the infinite by our own narrow limitations.

"Moreover, looking at the question from the other side, we find in animals complex organs of sense richly supplied with nerves, but the functions of which we are as yet powerless to explain. There may be fifty other senses as different from ours as sound is from sight; and even within the boundaries of our own senses there may be endless sounds which we cannot hear, and colors as different as red from green, of which we have no conception. These and a thousand other questions remain for solution. The familiar world which surrounds us may be a totally different place to other animals. To them it may be full of music which we cannot hear, of color which we cannot see, of sensations which we cannot conceive."

THE HARBOR SEAL.

Phoca vitulina.

By MANASSEH SMITH.

MOST of our readers are familiar with (at least the outer covering of) the fur seal, or Alaskan seal, as it is now commonly called, since the world's largest supply of the skins thereof is to-day obtained from the Alaskan waters, the Antarctic region having been nearly depopulated by unrestricted slaughter.

But few people, outside of our fishermen, know much of the habits of the harbor seal that still abounds on the Atlantic coast of North America, from the shores of Maine northward into and overlapping the domain of the Greenland seal (*P. Groenlandica*), while stray specimens of the family are still occasionally seen as far southward as Chesapeake Bay.

At the time of the early advent of Europeans to this country, *P. vitulina* was abundant as far south as the New Jersey coast, and congregated in large numbers on Robin's Reef, in New York Bay, and from that fact the reef derived its Dutch name of robyn—seal.

At the present time, I think that Saco Bay, on the coast of Maine (to which reference will be made later on), can be called the southern limit of their range in large numbers; certainly they are comparatively rare south of Cape Cod; while northward their range extends along the Labrador coast and to southern Greenland.

The pinnipeds—well named fin-footed—embracing the seals and walruses, are a sub-order of the order of *Feræ* or carnivorous mammals, and their life is mostly spent in aquatic pursuits—of fish.

From what causes and through what processes they have evolutionized to so wide a variation from their land-dwelling congeners, and whether the sea lion was evolved from the African lion, or the Polar bear from the sea bear, or all from some antediluvian cat or dog, are questions for whose answers I will refer the curious reader to scientists, such as Darwin or Huxley; but that the harbor seal and say the Chesapeake Bay dog were once one, though not since indivisible, I have no doubt. The tradition among the bay men, that the Chesapeake Bay dog is derived from a cross of the Newfoundland dog with the otter will scarcely be confirmed by the scientist.

But as we have, in popular parlance, sea lions, sea bears, sea cows, river horses, etc., I have often wondered that our harbor seal is not commonly known as sea dog; its head bears a strong resemblance to that of a dog, minus the ears; the cry of the mature seal is the bark, and its voice of anger the snarl and growl of a dog, while the cry of its young is an almost exact imitation of the whine of a puppy dog.

Notwithstanding its lack of education in preceding generations, its intelligence nearly equals that of the dog, and the many trick-performing, educated seals of our shows bear witness to an equal capacity for acquiring knowledge, while there are few animals so quickly and easily domesticated, or that show so strong an affection for their human master.

Stripped of his hairy (or furry) overcoat and of his fatty undershirt, the body of the seal displays the four legs of the dog, that were previously concealed from sight by these coverings that extended to beyond the knees and elbows; and stripped of his flesh, he displays what might well pass, with an ordinary observer, as the skeleton of a dog, the bones being slightly modified to accommodate the diverse pursuits of the animal.

In other words, wide apart as is the external appearance of the two animals, the difference between their internal anatomies is comparatively slight, and the otter would serve well as a connecting link between the two.

The muscular power of the seal is enormous, their speed in the water as marvelous as their movements on land are awkward, although the celerity with which they tumble from the rocks into the water, upon the least suspicion of danger, is also awkward for their would-be slayer; and the accounts of Arctic seal-hunters walking up to their prey and killing it with a club seem almost incredible to one whose only acquaintance is with the wary, sharp-eyed, keen-nosed harbor seal, whose powers of sight and hearing must be far greater than those of his Arctic brethren, and his bump of caution more highly developed, since, abundant as they are, it is comparatively seldom that man can approach so as to shoot them—when they are on the land.

Some two and a half miles seaward from Prout's Neck, the point of land that forms the northeastern boundary of Saco Bay, on the southern part of the coast of Maine, are two small islands named Stratton and Bluff, the latter containing about eight acres of grass land, and, at low tide, about thirty or forty acres of bare rocks and ledges, and the former about double the latter in size. At high water, the passage between the islands is about one-third of a mile in width. Bluff Island is uninhabited. There is a dwelling house, etc., on Stratton, erected some fifteen years ago. Previous to that time, both islands had been uninhabited since the Indians, in sixteen hundred and something, destroyed the first settlement of whites thereon. For many years these islands were a favorite resort of a few sportsmen friends and myself, for the purpose of shooting ducks, and we frequently spent a week at a time there, in a little hut on Stratton Island, built of rough stones, half under ground, with roof made of the cabin top of a wrecked vessel.

During my frequent visits to these islands I had frequent opportunities for, and spent many hours in, watching the habits of the seal.

They commence congregating there in the early autumn, and continue increasing in number until midwinter, when the herd numbers several hundred; their favorite roosting place is on Bluff Island, but few coming ashore on Stratton. Here they remain until May, when they scatter up and down the coast, following the fish into the bays, and even up our rivers for long distances, being occasionally seen as far up the Kennebec as Augusta, and at Bangor, on the Penobscot, tempted, doubtless, by the anadromous fish, shad, alewives, salmon, etc., that are then pushing up from the sea to their spawning beds, but the seals return in the fall to their former quarters.

When approaching the islands, during the time when the seals are there, I have rarely known it to fail that, before our boat got half way across from the Neck, one or more seals would appear near us, fall into the wake of the boat, and escort us to the landing, and again, when we left the islands, they would see us safely to the mainland.

Shooting upon the farther side of Stratton Island would seldom disturb the seals on Bluff, but if a boat put off from Stratton for Bluff, every seal would leave the latter before the boat got across, not only those in sight of the boat, but those on the opposite side, who could neither see, hear, nor smell the boat. Just how the warning of danger was passed from one to another I cannot say, but they had always timely notice of our approach, and no one of us ever succeeded in killing a seal upon the rocks there.

On one occasion, however, when several of us were crossing the channel between the islands, a seal lifted his head high out of water within ten yards of the boat, and I put a heavy charge of duck shot into his neck at the base of the skull, making a hole about an inch and a half in diameter, from which the blood poured in a stream, reddening the water for rods around. Contrary to custom, the seal did not sink immediately, having been killed so quickly that it could not expel the air from its lungs. We got alongside of it, but the man nearest was afraid to seize it, lest he should be bitten, and the boat went over the seal forcing it under, and we lost it, not having a gaff. The curious part of the story is this: The previous day I had estimated, from a partial count, that there were at least 300 seals in the herd; the day after this one was shot, not a seal was to be seen from either island, nor did they return that spring, although the date was a month or so earlier than their usual time for leaving the islands.

Undoubtedly, some of the seals, upon seeing the blood and dead body of their companion, gave the alarm to the others, and the whole herd left for safer quarters, and yet the shooting at ducks never seemed to seriously disturb them. Of course they would all take to the water when (or rather before) the first shot was fired on Bluff Island, but many would remain in the vicinity, and occasionally one would take under a dead or wounded duck, and often within an hour after we left Bluff Island the seal would begin to crawl out on the rocks again.

I will give one more incident, showing the intelligence of the seal, that came under my personal observation. Sitting, one day, at the window of the house on Stratton Island, I observed several herring gulls (*Larus argentatus*) hovering over some object in the water, and alighting near it. Presently one of the gulls jumped into the air, evidently alarmed, but from what cause I could not imagine. Soon another and still another rose with the same manifestations of fright or trouble, but I could discover no reason for their alarm.

Their actions puzzled me, as only one rose at a time, and none flew away, but, with the aid of a field glass, I saw that the object of attraction was a crippled duck (*Harelda glacialis*), local name old squaw, whose movements were very peculiar, and I was soon satisfied it was being pulled about by some other force than that of its own feet. My first thought was that a school of large fish was the cause of all this commotion; but, after a while, as a gull jumped into the air, I saw the head of a seal appear for an instant above the water in the place where the gull had been sitting. The mystery was now solved. Calling the attention of my companions to it, we watched the performance repeated for a long time, a dozen or more gulls having meanwhile collected there.

The duck could, apparently, neither fly nor dive, but the seal, seizing it by the legs, would push it this way and that, occasionally lifting it clear of the water, and the gulls would circle around and hover close to it. When a gull lit near it, the seal would leave the duck, come up under and attempt to seize the gull. For more than an hour this game went on with a persistency, on the part of the seal, worthy of greater success. As he failed to capture a gull, although once he plucked out a handful (or rather a mouthful) of feathers, probably the clearness of water and sky was against him, and the birds saw him in time to escape his jaws. At length the seal abandoned the sport and took in his decoy.

The question naturally arises, How did the seal acquire this art of decoying? It cannot be called instinct. That would have led him to devour the duck as soon as captured. Did his parents teach him the art? Did he acquire it in imitation of human fowlers who had used decoys in his presence? Or did he invent the process by his own unaided reasoning powers? Who shall say?

The Asiatic man, covering his head with the shell of a gourd, and wading out among water fowl to seize them, and the historic fox, with a bunch of moss in his mouth, swimming out among them, for the same purpose, are both tyros in the art compared to the skillful seal.

The damage done by seals to the Canadian salmon fisheries is enormous, and the quantity of fish consumed by them on the coast of Maine is beyond computation; but it is safe to say that each seal consumes a greater quantity of fish than does any fisherman's family in the State, and the total weight of fish consumed by seals on that coast must be many thousand tons. It may well be questioned if it is not an expensive luxury for the State to prohibit the killing of seals, as it has done in some localities.

Delicious as seal meat is reported by competent judges to be, our people still prefer fish upon their tables, and it is an open question which it is best to protect, the seal or the fish. The seal can take care of himself pretty well, without the help of the State of Maine, and not until our people learn his value as food is he likely to be hunted to the point of extermination.

One fact in the history of seals has never been satisfactorily explained, viz., their habit of swallowing good-sized pebbles, sometimes in large quantities. The fishermen believe it is done to increase their specific gravity, or, as they put it, so that they can dive deeper and easier, and claim that the fatter the seal is, and the deeper the water where he is feeding, the more pebbles will there be found in his stomach.

Many naturalists say that the stones are swallowed in order to aid the process of digestion, but the *modus operandi* they neglect to explain, and so shall I.

Do the naturalists mean that the pebble in the stomach of the seal performs a service similar to that done by the gravel in the gizzard of a fowl, and aids in grinding up the shells of mollusks and crustacea, such as clams, mussels, crabs, and lobsters, on all which the seal feeds at times? If so, my personal opinion favors the theory of the fishermen.

[Continued from SUPPLEMENT, No. 679, page 10850.]

YEAST: ITS MORPHOLOGY AND CULTURE.*

By A. GORDON SALAMON, A.R.S.M., F.I.C., F.C.S.

LECTURE I—CONTINUED.

By far the greater number of species are, however, developed by means of asci; an ascus being a large cell, usually the swollen extremity of an hyphal branch of the organ of fructification. The spores are developed within the ascus, and are then known as ascospores. This term possesses an especial significance for us because it has been shown that yeast may be caused to develop ascospores, and advantage has been taken of the observation to base thereon a reliable and invaluable system of yeast analysis.

It will be shown that this method places it within the power of the brewer not only to determine the exact composition of the yeast with which he is working, but also to secure the propagation of a species of yeast the purity of which is unquestionable. It has, however, done more than this. It has determined the position of yeast among fungi with tolerable certainty, and has put an end to the series of arguments wherewith it was sought to prove that the various yeasts did not represent absolute fungal species, but merely stages in the cycle of development of a more highly organized group. Thus it was stated, by those who were infected with what De Bary terms "the pleomorphic craze," that yeast, when grown in saccharine fluids, would exhibit the well known development of saccharomyces; if eaten by flies, it would develop in them the germs of the insect fungi or entomopthora; that these might complete their development as insect fungi, but they might also develop into mucor or into achyla (*saprolegniea*) if the flies fell into water. Finally, it was asserted that mucor placed in saccharine fluids would result in its transference into saccharomyces, and thus the pleomorphic cycle was completed. These statements, which were based upon inaccurate experiments, resulted in the enunciation of an ingenious but highly mischievous theory of fermentation, of which Fremy was the leading and certainly the most logical exponent. The complete study of the ascospore formation of yeast, as carried out by Reess and Hansen, has absolutely dissipated these erroneous views, has placed the question of yeast culture upon an entirely new basis, and has, moreover, rendered possible, and indeed probable, the realization of some of the most highly cherished ideas of the practical brewer.

It would be impossible, within the limits of these lectures, to do more than glance at the intricate questions connected with general fungology. For more detailed study the reader is referred to the works of De Bary and Berkeley. I need scarcely apologize for stating that I have drawn most of my information from the pages of the former master, because not to have done so would have been to risk inaccuracy and to have ignored the greatest authority upon the subject. The appended classification is compiled from his book, and may serve to show the relationship of yeast to other familiar fungal forms, in so far as they are at present regarded by the highest authorities.

Now we have seen how the development of root and shoot is subject to modification, until ultimately a merging into one thallus is effected. In the same way it is to be expected that mycelium and sporophore should

* Lectures before the Society of Arts, London, 1888. From the *Journal* of the Society.

FUNGI.

Thallophytes which have no chlorophyl.

Groups:

1. SERIES OF THE ASCOMYCETES.

Phycomycetes
So called because of close approximation to the algæ.

1. Peronosporeæ: Some live on the bodies of dead animals and plants; the greater number as parasites in the tissues of phanerogams—fertilization by male and female organs.
   Ancylisteæ: Parasites are fresh water algæ; closely related to peronosporeæ.
   Monoblepharis: Incompletely studied; closely related to peronosporeæ.

2. Saprolegnieæ: Closely resemble peronosporeæ; live on dead organic bodies in water, mostly of large growth; male sexual organs wanting, or do not perform fertilizing functions; spores in motile state when young issue from sporangium.

3. Mucorini: Plants of the dry land; mostly grow on dead organic bodies, especially animal excrement; some parasitic on other mucorini, closely connected with peronosporeæ and saprolegnieæ, but differ in forming zygospores and onidia. Subdivisions:
   (*a*) Mucoreæ: Spores found endogenously in terminal sporangia.
   (*b*) Chætocladieæ: Spores abjointed acrogenously one by one.
   (*c*) Piptocephalideæ: Spores formed acrogenously and serially by-cross septations.

4. Entomopthoreæ: Penetrate the cavities of bodies of living insects and there develop; form gonidiophores on hyphal branches; make their way through the body of the insect after its death, and complete their development on its outer surface.

5. Ascomycetes: Composed of branched hyphæ; always septate; all form spores in asci; the asci are sporocarps or parts of them, and often collected together into hymenia.
   (*a*) Ascomycetes bearing apothecium.
   (*b*) Ascomycetes bearing perithecium.
   (*c*) Cleistocarpus Ascomycetes: Spores released by rupturing cell wall.

6. Uredineæ: Closely allied to ascomycetes; all parasites or living phanerogams and ferns; many complete their development on one host; others obliged to migrate from one host to another in order to arrive at certain stages of their development.

2. DIVERGENT ASCOMYCETES OF DOUBTFUL POSITION.

Considered in connection with phycomycetes............

7. Chytridieæ: Microscopic; mostly live under water; swarm spores formed in sporangial cells. Subdivisions: 1. Rhizidieæ.
   2. Cladochytrieæ.
   3. Olpideæ.
   4. Synchitrieæ.

8. Protomyces and Ustilagineæ:
   Protomyces—parasites in intercellular spaces of umbelliferous plants.
   Ustilagineæ—endophytic parasites in phanerogamous plants; phylogenetically a more highly developed group proceeding from the chytridieæ.

Considered in connection with 5, 10, and 6..................

9. Doubtful Ascomycetes:
   Laboulbenieæ—grow on outer surface of beetles, have no mycelium.
   Exoascus—parasitic on the surface of parts of living plants.
   Saccharomyces—YEAST.*

	10. Basidiomycetes: *Basidium*—mother cell from which spores are acrogenously abjointed. Basidia common to all members of the group. Subdivisions: *Hymenomycetes* (containing edible mushroom) closely connected with uredineæ. *Gasteromycetes*—
3. MYCETOZOA.	Resemblance in life and nutrition, and in structure and biological character, between their organs of reproduction and those of fungi. Subdivisions: *Myxomycetes* (or slime fungi). *Acrasieæ*.
4. DOUBTFUL MYCETOZOA.	
5. SCHIZOMYCETES, OR FISSION-FUNGI.	Bacteria, at present including some chlorophyl forms. Subdivisions: *Endosporous*—spirillum, bacilli (rods, vibrios, etc.) *Arthosporous*—spores capable of giving rise to new combinations.

CLASSIFICATION OF FUNGI ACCORDING TO NUTRITIVE ADAPTATION.

Classified according to nutritive adaptation.

1. Pure saprophytes............Comprising by far the greater number of the known fungi.
2. Facultative parasites........May be able to obtain full development both as saprophyte and parasite. (Fungi which attack the bodies of living animals.)

Eg. Aspergillus.

3. Obligate parasites...........Subdivisions:
   (*a*) Strictly obligate parasites. Living only as parasites. *Saprolegnieæ* (salmon disease).
   (*b*) Facultative parasites. Development possible as saprophyte. (Certain saprophytic moulds, causing orchard fruit to rot.)

SPROUTING FUNGI.

ASCOGENOUS.	NON-ASCOGENOUS.
Saccharomyces Cerevisiæ	Saccharomyces Apiculatus.
" Ellipsoideus.	" Glutinis.
" Pastorianus.	" Albicans (thrush).
	" Exiguus.
	" Conglomeratus (?).
	Monilia candida.
	Chalara Mycoderma.*
	Torula.
	Exoascus.
	Dothidea Ribesia.
	Nectria (some species).
	Dematium Pullulans.
	Mucorini (some species).
	Ustilagineæ (some species).
	Tremellineæ (some species).
	Fumago.
	Exobasidium.
	S. Mycoderma.

* Can form *hyphæ* under favorable conditions.

become merged, or that we should meet with some fungi in which mycelia are not developed. Again, the typical hyphal form with transverse septation may be departed from. That such forms are referable to the characteristic hyphal one can scarcely be doubted, but it may often require long, studious investigations to discover the necessary proof. Among such modifications may be classed the so-called sprouting fungi, of which yeast is a type, and which are detailed above.

The importance of subdividing them into those

FIG. 4.—DEMATIUM PULLULANS.

A, *x x*, portion of a row of cells with brown membranes forming tubes and occasionally sprouts in a saccharine solution (magnified 390 times). B, portion of a filament vegetating in a saccharine solution, and covered with sprout cells (magnified nearly 300 times).—*De Bary.*

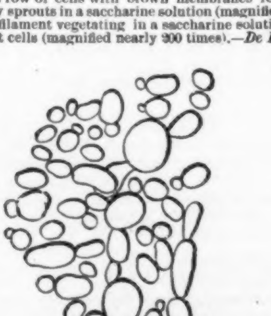


FIG. 5.—MONILIA CANDIDA (Hansen).

which form ascospores and those which do not will be made apparent as we proceed. It may suffice to remark here that *Dematium pullulans* and *Monilia candida* (Figs. 4 and 5) have often been mistaken for yeast, with which they have many morphological points in common. Their identification is rendered comparatively easy by reference to the method of ascospore analysis.

It was formerly imagined that alcoholic fermentation could only be produced by sprouting fungi, but this has been disproved by the researches of Pasteur and others. Recent investigation, indeed, favors the view that many other forms, including some bacteria, will be found which, under certain conditions, may be made to develop this property. The following table includes all the fungi known to be capable of inciting alcoholic fermentation.

FUNGI.

INCITERS OF ALCOHOLIC FERMENTATION.	NON-INCITERS OF ALCOHOLIC FERMENTATION.
Saccharomyces Cerevisiæ.	Saccharomyces Glutinis.
" Ellipsoideus.	" Mycoderma (generally).
" Pastorianus.	Exoascus Pruni.
" Apiculatus.	Dematium Pullulans.
" Exiguus.	Fumago.
" Albicans.	
" Mycoderma (rarely).	
" Conglomeratus (?).	
Mucor Racemous (*a*) Hyphal form.	
(*b*) Sprouting form.	
" Circinelloides.	
" Spinosus, } small.	
" Stolonifer, } small.	
Exoascus Alnitorquus (Sadebeck).	
Torula.	
Eurotium Aspergillus Glaucus.	
(Hyphal form—Pasteur).	

Of these it should be remarked that some have only given evidence of the power to a limited extent. For instance, *S. albicans*—the fungus which is said to produce *apthæ*, or the disease known as "thrush"—will, if transferred to saccharine solutions, incite alcoholic fermentation, but of a very mild character compared with that of *S. cerevisiæ*. It would be rash to assert that some method may not hereafter be found of causing fungi, other than those at present commercially employed, to develop alcoholic fermentation with such vigor as to lead to their use in practice; but in the existing state of knowledge these functions are exclusively reserved for the saccharomyces.

Having now become familiar with some of the more general considerations respecting yeast, we are in a better position to approach and appreciate its more detailed study. I propose that we should devote ourselves to this task in the following and succeeding lectures, and that we should dwell more especially upon those observations of which foreigners have already taken practical advantage with signal success.

KAURI GUM INDUSTRY.

NEAR the west coast of the North Islands, says Mr. Ralph Robinson, we found here and there a noble kauri, the Dammara australis, one of which measured upward of 32 feet in circumference. The largest known specimen in the colony measures about 72 feet in circumference, reaches a height of 80 feet without a single branch, and is estimated to have taken about two thousand years to grow.

There were many other trees in an advanced state of decay, covered with parasites, which gave them a very weird appearance. Hillsides covered with tree ferns, Cyathæa medullaris (Maori name—Punga), hundreds or perhaps even thousands standing closely together, with here and there a nikau palm with its pinkish flowers or red berries attached to the base of the leaves. The umbrella and scented ferns were also in abundance. The first half of our journey being completed at a place known as Big Muddy Creek, but on this occasion a small stream of very clear water, we halted and soon had a supply of hot tea and a fair supply of solids as lunch. The other half of the journey was very like the first half, until we reached the west coast with its rocks and boiling surf as far as the eye could see. It is common here on such excursions either to sleep out in the open air or to make use of an uninhabited gum digger's hut or disused whare, not always the most desirable abode, as in many cases you are brought in contact with too many bedfellows in the shape of fleas. But Kare Kare has its idle saw-mill and workmen's empty huts, in one of which we took up our abode. Our cooking utensils were of the simplest description, tin cans (billies) and a few preserved meat tins playing a very important part. It was here we met with a camp of gum diggers and had the opportunity of gaining most of the little information here given relative to the kauri gum industry. They go out in parties of three or more, carrying with them their spades, spears, and bags, or they may have left their spades in the bush the night before. They usually went to their work between 7 and 8 o'clock in the morning, returning again about 4 o'clock in the afternoon, bringing with them what gum they had got. Friday was usually clearing up day, that is, they sorted and scraped their gum and bartered it in return for stores to the caretaker of the saw-mill, drawing the balance in cash or check before going to town. The store-keeper in his turn sold it to the gum merchant.

There are two kinds of gum fields, the summer and the winter. It is usual to work on the ridges, that is, the higher ground, during the winter months, because then the rain softens the hard, clayey ground and makes the labor much lighter; but in summer, when the ridges become too hard and the low-lying swamps sufficiently dry, they transfer their operations to them. The gum is found much nearer the surface on the ranges than in the swamps, being only a few inches below the surface, and sometimes even projecting above, while in the swamps it may be found to a depth of several feet, the soil of the higher ground having been washed away with the heavy rains and deposited in the swamps, burying the gum deeper each successive year. The spear is a sharp-pointed steel rod with a wooden handle, and this is thrust down into the earth to ascertain if gum is present. If gum is proved to be present, then digging commences and the whole spot dug over until they suppose they have got all the gum out. It usually occurs in very irregular, rough pieces, about the size of a hen's egg, looking like a piece of very rough clay. This, when the outside is scraped off with a pocket-knife, is the kauri gum usually met with in commerce, and worth about 35s. per cwt. on the spot. The smaller pieces are only washed and dried, and do not bring nearly such a good price. As a rule the scrapings are not saved, not being worth more than 20s. for a large sackful. They are used for lighting fires and making fire lighters. The gum fusing and burning soon sets the sticks and logs on fire, the gum giving off a white smoke and aromatic smell. Sometimes very large pieces, a cwt. or more, of transparent and almost colorless gum are found near the decayed root of a tree, probably the gum of the original tree. This brings a very much higher price, and is used for making personal ornaments. It is easily worked with a knife into any shape, and polished with a soft rag and kerosene oil. At times large masses of the gum may be found exuding from the living tree, but this gum is not so good for varnish making as the fossil gum. Three or four thousand men are usually engaged in digging the gum, and can earn in districts where the gum is fairly plentiful 30s. to 40s. a week. As the cost of living is very small, they could easily save money; but, being cut off from all civilization while at work, they speedily spend and waste all their savings when they go to town. The gum is also found in considerable quantities, but of dark color, in the coal deposits, showing the antiquity of the kauri forests. There was 4,920 tons of gum exported from Auckland in 1886, the value of which was £257,653, being at the rate of rather less than £2 12s. per cwt. The gum was dearer then than now, and there is the cost of packing, sorting, warehousing, carriage from the gum fields, and other expenses to be added to the first cost.

The kauri gum industry is confined to the North Island, as it is only in the north that the kauri pine grows; thus the unemployed of Auckland are not so badly off as those in the south, always having the gum fields to fall back upon as a last resource; a last one on account of the hardships to be gone through, especially when there is a wife and family, and because an inexperienced digger may be a long time before he finds gum enough to find him with food. A very large portion of the kauri forests having passed into the hands of a syndicate, it is very probable the gum digging will be regulated, and in all likelihood the price of the gum will advance.—*Oil, Paint and Drug Reporter.*

AUCTION SALE OF THE GREAT EASTERN.

THE last act in the career of the celebrated vessel known as the Great Eastern took place near Liverpool in November last, when the ship was put up at auction to be sold to the highest bidders, who were to tear her in pieces and lug off their booty at their own expense. The sellers were Bath & Co., of Liverpool, who paid $80,000 for the vessel and sold her out at auction for $290,000, thus realizing a handsome profit, being, we believe, the first and only profit ever made by the unfortunate ship for any of her various owners.

Our engraving is from the *London Graphic*, and shows the scene on board at the time of the sale, which appropriately closed during a heavy rain storm. It will take a year and a half to demolish and distribute the vast mass of material of which the vessel is composed.

The Great Eastern was planned by Mr. Brunel and built by Mr. Scott Russell, to accomplish the voyage to the East, round the Cape, without having to stop by the way for coal, and was originally intended to take some 3,000 first, second, and third class passengers and a large cargo. Her length was 692 feet, her breadth 83 feet, and the depth of her hold was 24 feet, and her registered tonnage 18,914 tons. She was fitted with both paddle and screw engines, carried five funnels, each 100 feet high, and had a coal bunker space of 10,000 tons. She was built at Millwall, and great difficulty was experienced in the launch, which occupied three months, and cost £60,000.

In 1859 the mammoth steamship started on her first trip to the United States, but had to put back through the explosion of a steam pipe, by which a number of persons were killed and injured. Next year she reached New York, and made several trips across the Atlantic, but the receipts were unequal to the enormous expenses. In 1861, she was utilized as a troop ship to take the Guards to Canada, but it was not until 1865 that her true vocation was considered to have been found—namely, to lay a telegraph cable between England and America.

In this work she was occupied for some years—an attempt being made in 1867 to utilize her as a passenger ship between New York and Havre during the Paris exhibition—but when there were no more cables to lay she was relegated to idleness and Sheerness, where cockney "trippers" were admitted to view her interior at a shilling a head. Two years ago the vessel was taken over by a syndicate, and stationed in the Mersey as a species of People's Palace of Amusement, being subsequently transferred to Dublin. After a brief visit to the Clyde, the Great Eastern was sent on her last voyage to the Mersey, where, recently, she was beached near New Ferry, on the Cheshire shore, to be eventually handed over to the dismantling hammer. Even to the last her ill-fortune appeared to attend her, as during her journey from the Clyde she encountered a gale, during which the tug was obliged to cast her loose, while her own engines, being stopped for a short time, the great vessel became unmanageable, and for hours rolled about at the mercy of the wind and waves. On the weather moderating, however, she was again taken in charge, and finally towed by the tug Stormcock to her last berth.—*London Graphic.*

ENGLISH CASTINGS FOR AMERICA.

THE *Chicago Inter-Ocean* says a person thoroughly familiar with all the facts, figures, and bearings of the matter of which he speaks, was recently interviewed by a reporter on the subject of the contract for furnishing the castings for the Denver Street Cable Railroad, which was alluded to in a late issue. He said:

"The contract is for 5,000 tons of castings for the Denver Street Cable Railroad Company. There were intimations received by home firms that they would have foreign competitors. The consequence of these intimations was that the Americans entering into competition for the contract made very low bids, being well aware what their English competitors would do in the way of low prices. A letter from Denver says that the contract, after all, has been let to two firms in Bradford, England. The bid of the American parties was under $39 per ton, delivered in Denver. The contract has been taken by the English parties for still less. The castings, consequently, will be made in England, shipped to Galveston, Texas, and thence taken to Denver by the Atchison, Topeka, and Santa Fe Railroad. Now, the Denver Street Cable Railroad Company has effected a saving of nearly $4,500 by taking advantage of this difference in prices between the American and the foreign bidders, and yet the price asked by the American bidders was based on less than 1¼c. a lb. in Chicago. The basis of bids made by the Americans was on pig iron in the neighborhood of $16 per ton in Chicago; and the English firms have to pay a duty of 40 per cent. *ad valorem*, and still they are enabled to beat American competitors on large contracts, and at figures that allow scarcely any margin of profit to the American manufacturer. What would be the result to American foundrymen if the duty was still further reduced? This contract going to England means the non-employment of over 100 moulders for six months, of over 200 other employes in mining, manufacturing iron and fuel for the same period of time. It means the loss of over 12,000 tons of ore to American consumption, and over 15,000 tons of fuel. The labor item in this matter amounts, or would do if the contract had been let here, to over $100,000 in wages to American workingmen, not including the labor of transportation. The $100,000, in other words, simply includes the wages for mechanical labor."

"What are the relative wages of American and English moulders?" "The wages here for moulders are about $2.75 per day, and in England about $1.25 per day. But this latter price is only paid in England to first-class moulders, to the very best, while the lower class of their moulders do not get over 90c. per day, the average wages here being $2.75 per day. I would add that there is a large class of work given out here in quantities, such as car work and bridge work, that is made from standard patterns and in large quantities, that the English firms can bid on, and that they have not hitherto done so to any extent may be accounted for, probably, from their not understanding the large field there is here for such work."

It is also stated that there were four Chicago bidders on this Denver job, in addition to the bids from foundries in St. Louis, Cincinnati, Kansas City, Belleville, Ill., Birmingham, Ala., and Omaha. The successful placing of the Denver contract in England is partially explained by the fact that a cable railway of St. Joseph, Mo., had previously contracted for a cable plant in Bradford, England.

The following correspondence speaks for itself:

W. M. SHEPHERD, ESQ., Editor of *Herald*, St. Joseph, Mo.: The statement has been made that the engines, driving machinery, pulley yokes, and rods, in fact the entire ironwork to be used in the construction of a cable street roadway in St. Joseph, was manufactured at Bradford, England. Is this statement correct? (Signed) JOHN C. ORRICK.

The answer is as follows:

All the materials were purchased at Bradford, England. So say the officers of the cable road.

(Signed) W. M. SHEPHERD.

We are informed that the Denver contract for yokes was on a basis of $38 per ton delivered. The cost of making these castings in England and laying them down in Denver is about as follows:

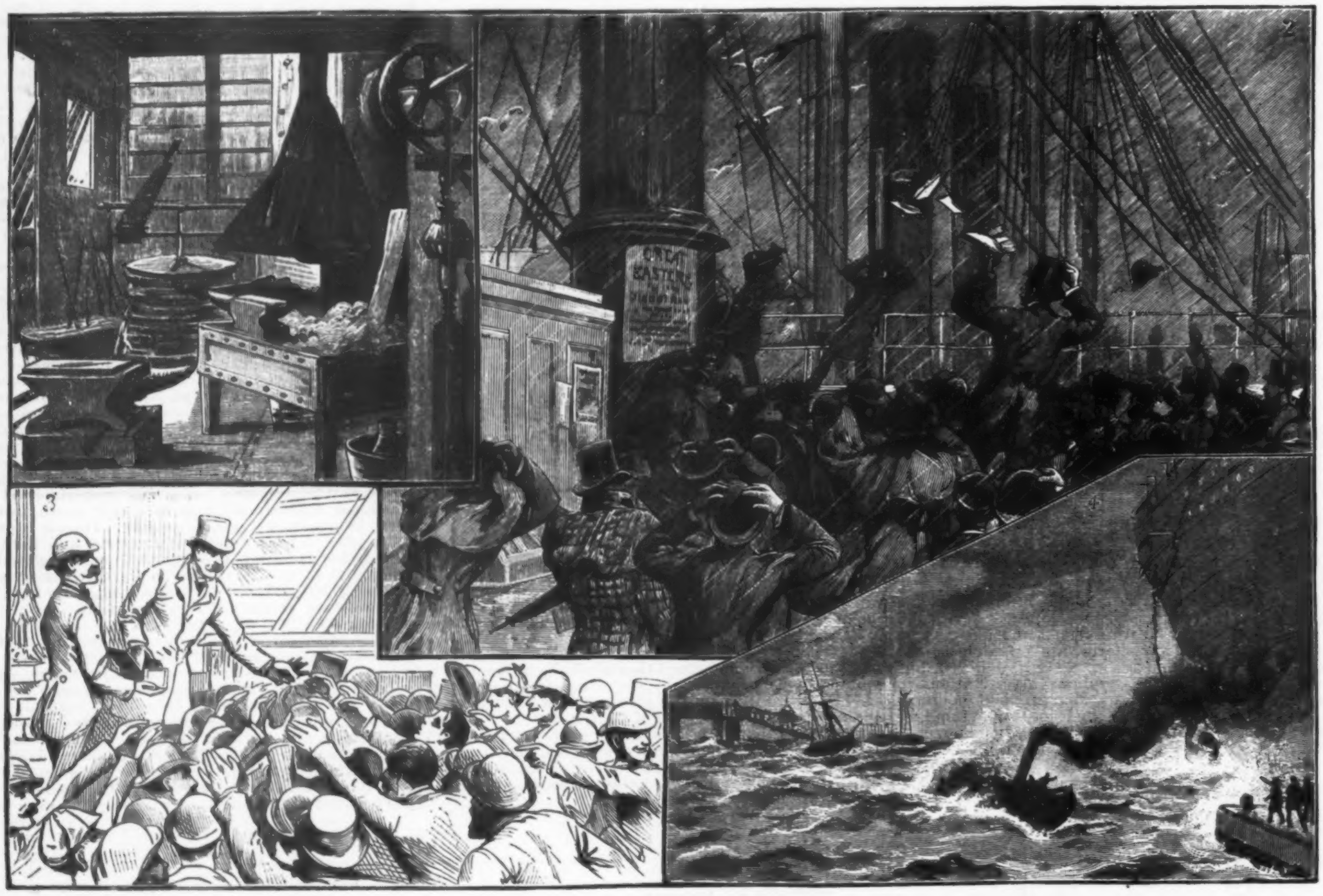
Pig iron	$9.00
Casting	3.50
Duty, 40 per cent. *ad valorem*	5.00
Freight—water and rail	7.00
Margin for contingencies, etc	3.00
Total cost in Denver	$27.50

The foundries in St. Louis, Litchfield, and Belleville have been doing a great deal of this class of work for the cable roads in this city and Kansas City.

The Denver and St. Joseph contracts referred to involve the expenditure of at least $400,000, of which at least three-fourths is labor.

STATE OF MISSOURI, }
COUNTY OF BUCHANAN. }

J. M. Huffman, being duly sworn, deposes and says he is the president of the Wyatt Park Railway, of St. Joseph, Mo., that said company did contract with Thalimer & Lighthall for all material and labor to build and equip about five miles of cable railway in said city of St. Joseph, and that said Thalimer & Lighthall did sub-contract for engines, driving machinery, yokes, and other castings to be used in construction of said cable railway with firms in England, and that there was sent to the city of St. Joseph a sample of said yokes for said cable railway that was cast in Brad-



1. The smith's shop: a relic of the Atlantic cable, 1866. 2. Auctioneering under difficulties: the auctioneer at sea. 3. Spirited bidding: cigars round at the end of the day's sale. 4. Her proverbial ill-luck pursues her: bidders going on board in a gale.

THE GREAT EASTERN UNDER THE HAMMER.

ford, England, and on which was cast the following, to wit: On one side, "Thornton & Gribben, manufacturers, Bradford, England." On one side, "A. H. Lighthall, 1888." And there were stored in United States bonded warehouse in the city of New York, July, 1888, not less than 250 tons of said yokes awaiting shipment.

(Signed) J. M. HUFFMAN, Prest.

[Continued from SUPPLEMENT, No. 679, page 10844.]

RADII OF CURVATURE GEOMETRICALLY DETERMINED.

By Prof. C. W. MACCORD, Sc.D.

IX.—THE PARABOLA.

IN Fig. 30, let L M be the axis, D L D the directrix, F the focus, V the vertex of the parabola W P V X. Let E P B be tangent to the curve at P; it bisects the angle between P F drawn to the focus, and P A drawn perpendicular to the directrix, and is, therefore, perpendicular to A F, which it bisects at B, and the normal at P is parallel to A F.

Similarly, the tangent at W is perpendicular to F N, and bisects it at O; and B O is parallel to D D, and when produced is tangent to the parabola at the vertex V.

The evolute C R U is readily mapped out by drawing a series of normals. And the center of curvature may be found, as in previous cases, by determining the simultaneous motions of the two points upon the normal; and also, as in preceding examples, we may take the point of normalcy for one of these moving points and the instantaneous axis of the tangent for the other.

In order to determine the locus of this instantaneous axis, let us suppose the tangent to be limited in one direction by the line drawn from the focus to the foot of the perpendicular let fall from the point of tangency upon the directrix (as, for instance, by the points B O, in Fig. 30).

Then, as already shown, this extremity must move in a vertical line through V; therefore, the instantaneous axis will be found in a horizontal line through the same extremity. Thus, when the moving line is tangent at P the instantaneous axis is at I, the intersection of the normal with the horizontal line through B; and, for the point of tangency W, it is at J, where the normal through W cuts the horizontal line through O, it being kept always in mind that the tangent is not regarded as inextensible, but as continually lengthening, or, to use a previous illustration, if we imagine the tangent as an inflexible wire, B is considered a definite point in its length, and P as a bead sliding upon the wire.

The required locus, then, is also very easily constructed, and it is a curve F I K which passes through the focus. For by the above process we have made P I parallel and equal to A B, and I B parallel and equal to P A; that is to say, the instantaneous axis is always as far from V O as the corresponding point of tangency is from D D; now, at the vertex, V O is itself the tangent, and V bisects F L, whence the focus F is then the instantaneous axis.

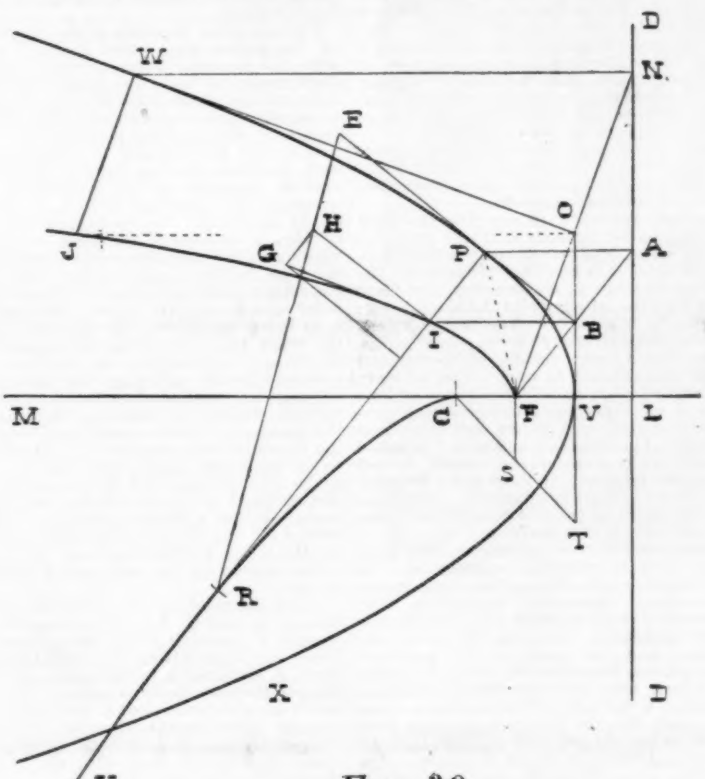
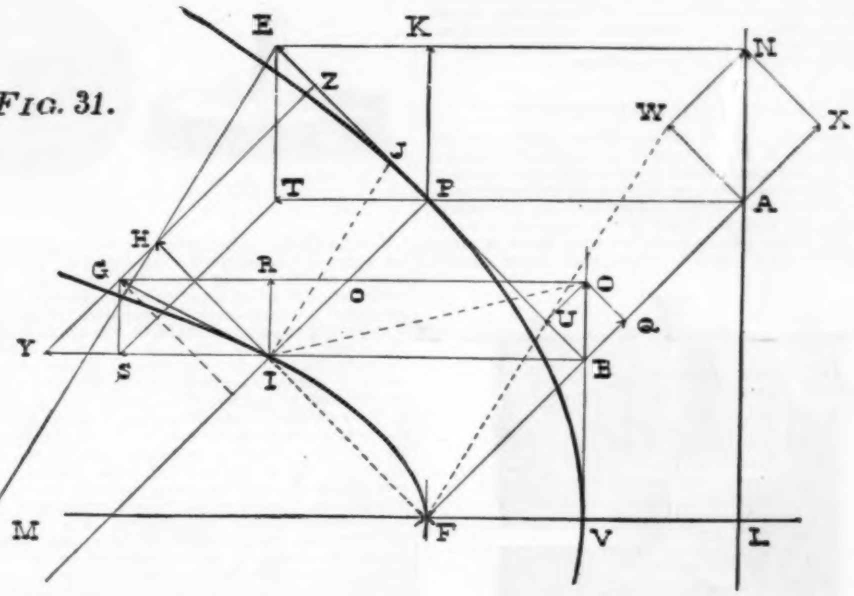


FIG. 30.

FIG. 31.



We thus see that the point of tangency and the instantaneous axis approach or recede from the directrix at the same rate, or, in other words, that the horizontal components of their motions are equal. In regard to the vertical components, that of the instantaneous axis is half that of the point of tangency; for B O = ½ A N. Since this holds true at the vertex, where the horizontal components vanish, the radius of curvature at that point is very readily found, thus, let V T be the motion of V, then F S = ½ V T will be the motion of the instantaneous axis F, and T S cuts L M in C the center of curvature; the distance C V being evidently equal to F L or 2 F V, as it ought to be, in accordance with the results of analysis.

If the radius of curvature at any other point on the parabola, as, for instance, P, is required, we may assume for it any velocity as P E; we must then determine the corresponding motion I G of the instantaneous axis, and find its component I H perpendicular to the normal; then E H produced will cut the normal in R the center of curvature.

The manner of executing this process in detail will be understood by the aid of Fig. 31. From P draw P A perpendicular to the directrix, join A F, and bisect it at B, then draw through B a horizontal line cutting the normal through P, at I the instantaneous axis. Resolve the assumed motion P E into its horizontal and vertical components P T, P K; then, as above shown, the horizontal component I S, of the motion of the instantaneous axis, is equal to P T. Produce E K to cut the direction in N; then, by reference to Fig. 30, it will appear that B O, the vertical motion of B, is equal to ½ A N, and I R, the vertical component of the motion of I, is equal to B O. Completing the parallelogram, we have I G, the required motion of the instantaneous axis, whence I H, the component perpendicular to the normal, is at once found.

There is another method of determining the motion of the instantaneous axis, closely analogous to that employed in the two preceding articles.

Considering this axis as the intersection of two moving lines, we may suppose each in turn to remain stationary for the moment, ascertain the effect of the motion of the other, and then combine these two results.

Let us first imagine the normal at P to be fixed; then, the horizontal line through B moving vertically upward with velocity B O, the intersection I with the normal will move along I P with velocity I C.

Next, suppose the horizontal line to be momentarily stationary; the normal is a perpendicular to the tangent at P, which point is moving through space with the assumed velocity P E. But P is not receding from B at that rate, because the motion of B has a component B U, also in the same direction along the tangent as that in which P is moving. And it is to be noted that under the present supposition the distance B I can be increased only by the effect of the motion of P relatively to B; which is P Z, determined by setting back E Z equal to U B.

Then drawing through Z a parallel to P I, cutting B I produced in Y, and completing the parallelogram Y I C G, the diagonal I G will be the required resultant motion of the instantaneous axis.

It need hardly be pointed out that the above process may be to some extent inverted; instead of assuming the velocity of P, we may assume B O, the motion of B regarded as the extremity of the tangent; then producing F B to cut the directrix in A, we have A N = 2 B O for the vertical component of the motion of P; knowing the direction of the resultant, its magnitude is ascertained by drawing the horizontal line through N, cutting P Z produced, in the point E; after which we proceed as before.

These operations, it may be remarked, are based upon a consideration of the action of the apparatus for drawing the parabola by continuous motion, illustrated in the SCIENTIFIC AMERICAN SUPPLEMENT, No. 535.

By reference to the description of that instrument, it will be seen that if the two racks move with the velocities represented by A N, B O, in Fig. 31, the bar pivoted at the focus will rotate about F with an angular velocity represented by the angle A F W, and the sockets will slide along that bar with the linear velocities B Q, A X. The point P of the slotted piece connected to the inner socket must move in the direction of the tangent, and with a velocity P J equal to B U, that component of B's motion which has the same direction. Or, otherwise, since the slotted piece is rotating about the instantaneous axis I, we may determine P J by making the angle P I J equal to the angle B I O. But because the sliding blocks which carry the pencil must move in the direction and with the velocity P E, it is seen that the difference J E represents the rate of sliding along the tangential slot, and P T the rate of sliding in the horizontal slide.

ANOTHER METHOD, INTRODUCING A NEW PRINCIPLE.

Thus far we have adhered to the mode of operation originally set forth, that is, determining the simultaneous motions of two points upon the normal.

But the motion of one point will suffice, if we have any means of ascertaining the law according to which the direction of the normal varies, independently of the fact that it is always perpendicular to the tangent.

And this can be done in the case of the instrument under consideration. The motions of the two sockets, as controlled by the wheels and racks, determine the motion of the pencil, and also of the tangential slotted piece, independently of the bar pivoted at the focus, which latter is not an essential part of the mechanism.

But, when it is used, we observe that the same motions of the sockets also determine the angular motion of this bar about the focus; and again, that the normal is always parallel to this bar.

Accordingly, referring again to Fig. 31, we may proceed in this wise: The motion B O of the point B determines, as previously explained, the motion P E of the point P; the normal P I is not only parallel to B F at the instant, but moves so as always to be parallel to it. Now, B F is rotating about F, with an angular velocity represented by B F U; therefore the normal must be rotating about a center lying upon P I produced (that is to say, upon the normal itself), found by drawing through E a parallel to U F. And should the intersection of this parallel with the normal be inconveniently remote, as in the diagram, the similar triangles enable us to determine the value of the radius of curvature by the proportion

U B : F B :: E P : radius sought.

The graphic process of finding the center of curvature, it will be observed, is much simplified by the introduction of this new principle; and, as will be shown in a subsequent paper, the gain is still more pronounced in dealing with the hyperbola.

THE SIBLEY COLLEGE OF MECHANICAL ENGINEERING AND THE MECHANIC ARTS.

THIS college was founded and endowed by the liberal gifts of the late Hon. Hiram Sibley, of Rochester, who in the year 1870 gave about thirty thousand dollars for the erection of a suitable building for the department of mechanic arts. He also gave ten thousand dollars for increasing its equipment of tools, machines, etc., and afterward made a further gift of fifty thousand dollars for the endowment of the Sibley professorship of practical mechanics and machine construction. During the years 1883 to 1887 he gave more than seventy-five thousand dollars for the purchase of models, the extension of the Sibley College buildings, and the building and equipping of a complete set of

work-shops. The total amount thus presented to Cornell University is nearly one hundred and fifty thousand dollars.

Sibley College is the school of mechanical engineering and of mechanic arts of Cornell University. The college is divided into three principal departments: that of mechanical engineering, including a laboratory in which experimental work and investigations are conducted; a department of mechanic arts, or shop-work; and a department of drawing and machine design. The first named is presided over by the Director, Dr. R. H. Thurston, who is also the professor of mechanical engineering.

THE MECHANICAL LABORATORY, which is the department of demonstration and experimental research of Sibley College, and in which not only instruction but investigation is conducted, is located in the annex of Sibley College, in several rooms of good height, well lighted on all sides, and carefully fitted up for the purpose for which they are designed. It occupies the whole lower floor, a space one hundred and fifty feet long by forty feet wide, and represents the latest contributions of Mr. Sibley to the University. It is supplied with the apparatus of experimental work in the determination of the power and efficiency of the several motors, including steam engines, and the turbine driving the machinery of the establishment; with boiler-testing plant and instruments; and with a number of machines for testing lubricants and the strength of metals. Among these is the "autographic testing machine," which produces an autographic record of the results of the test of any metal which may be placed within its jaws, securing exact measures of the strength, the ductility, the elasticity, the resilience or shock-resisting power, the elastic limit, etc., of the material. Several steam engines and boilers, air and gas engines, several kinds of dynamometers, lubricant-testing machines, standard pressure-gauges, and other apparatus and instruments of precision employed by the engineer in such researches as he is called upon, in the course of his professional work, to make, are all collected here.

THE PHYSICAL LABORATORY.—The rooms of the physical department occupy the first floor and the basement of the chemical and physical building. Piers are provided in several of the rooms for apparatus requiring immovable support, and some of the basement rooms have solid floors of cement, upon any part of which galvanometers, etc., may be used. The lecture room on the first floor has fixed seats for one hundred and fifty-four students. The arrangements for experimental demonstrations are most complete. Gas, water, steam, oxygen, hydrogen, compressed air, blast, and vacuum cocks are within easy reach of the lecturer, and dynamo and battery currents are always at hand, and under complete control from the lecture table. A masonry pier, four by twelve feet, permits the use in the lecture room of apparatus that could otherwise only be used in the laboratory. A small turbine on the lecture table furnishes power for a variety of experiments. Lanterns with the lime or electric light are always in readiness for use when their use can in any way aid a demonstration. Adjacent to the lecture room are the apparatus rooms, serving also, in part, as laboratories. On the same floor are other laboratory rooms, among which may be mentioned one for photometry, without windows, and painted black throughout.

The equipment of the physical department comprises many fine instruments of precision. The standard clock, having Professor Young's gravity escapement, is placed in a room provided with double walls, and actuates two chronographs by which the time observations of the laboratory are recorded. A very perfect automatic dividing engine, a large comparator, a standard yard and meter, an electro-calorimeter of a platinum wire resistance in a hard rubber tank, a spectrometer reading to seconds, sets of resistance coils, and galvanometers of various forms are among the instruments. For magnetic and other measurements by the magnetic needle, a special building free from iron has been erected. In this are placed the magnetometers and the instruments for the accurate measurement of currents and potentials. Of the latter is the large tangent galvanometer, constructed at the University, with coils respectively one and six-tenths and two meters in diameter, and giving deflections to ten seconds. Several dynamos of different styles and capacities, ranging from one thousand to ten thousand watts, and a special engine for driving them, having a governor adjusted to control the speed with extreme precision, are included in the equipment. Three of these dynamos are mounted on Professor Brackett's dynamometer cradles, for measuring the power absorbed, or transmitted if the machine is used as a motor. For dynamo tests a resistance of naked German silver wire has been provided, which is arranged in about one hundred sections capable of combination in all possible ways. Combined in series they furnish a resistance of 2,200 ohms, capable of carrying four amperes. A very valuable adjunct is a well-equipped workshop connected with the department, where a skilled mechanician is constantly employed in making apparatus. Some of the most valuable instruments in the collection have been made in this shop.

The museums and collections of the Sibley College of Mechanical Engineering and Mechanic Arts are of exceptional extent, value, and interest. The two principal rooms on the first floor of the main building are devoted to the purposes of a museum of illustrative apparatus, machinery, products of the manufacturing industries, and collections exhibiting processes and methods of manufacture, new inventions, the growth of standard forms of motors, and other collections of value in the courses of technical instruction given in the college. In the west museum are placed the Reuleaux collection of models of kinematic devices and movements, which is, so far as known, the only complete collection on this continent, and is one of the very few in the world. Besides these are the Schroeder and other models, exhibiting the forms and proportions of parts of machinery, the construction of steam engines and other machines, and methods of making connections. In the east museum are placed a large number of samples of machines constructed by the best makers, to illustrate their special forms and methods of manufacture. Among these are several beautifully finished samples of steam pumps, "sectioned" to exhibit their internal construction and arrangement, steam boiler injectors similarly divided, governors for steam engines, water wheels and other motors, devices for lubrication, shafting and pulleys, couplings, and other apparatus for the transmission of power, both by shafting and by wire-rope transmission. The lecture rooms of the Sibley College, each being devoted to a specified line of instruction and list of subjects, are each supplied with a collection of materials, of drawings, and of models and machines, especially adapted to the wants of the lecturer in each subject. Thus the lecture room of the instructor in "Materials of Engineering" contains a fine collection of samples of all the metals in common use in the arts, with samples of ores and of special intermediate products, exhibiting the processes of reduction and manufacture. Among these are specimens of the whole range of copper-tin and copper-zinc alloys, and of the "kalchoids" produced by their mixture, such as were the subjects of investigations made by the committee on alloys of the United States Board appointed by President Grant by authority of Congress, in the year 1875. The collection is supplemented by other alloys produced later by the director, and is one which has no known superior, and is perhaps unequaled. The course in machine design is illustrated by the standard forms of parts of machinery. The course of instruction in mechanical engineering is illustrated by a fine collection of steam engines of various well known types, gas and vapor engines, water wheels, and other motors, models and drawings of every standard or historical form of prime mover, of parts of machines, and of completed machinery.

The collections of the department of drawing include a large variety of studies of natural and conventional forms, shaded and in outline, geometrical models, casts and illustrations of historical ornament.

The workshops are supplied with every needed kind of machine or tool, including lathes, of our own and other makes, and hand and bench tools sufficient to meet the wants of over one hundred students of the first year, in woodworking; in the foundry and forge all needed tools for a class of eighty in the second year; in the machine shop, lathes from the best builders, and others made in the university shops, planes, drills, milling machines, and a great variety of special and hand tools which are sufficient to work a class of sixty or seventy of the third year, and fifty or sixty seniors.

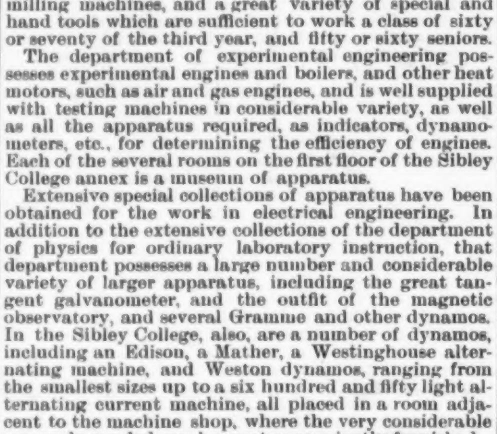
The department of experimental engineering possesses experimental engines and boilers, and other heat motors, such as air and gas engines, and is well supplied with testing machines in considerable variety, as well as all the apparatus required, as indicators, dynamometers, etc., for determining the efficiency of engines. Each of the several rooms on the first floor of the Sibley College annex is a museum of apparatus.

Extensive special collections of apparatus have been obtained for the work in electrical engineering. In addition to the extensive collections of the department of physics for ordinary laboratory instruction, that department possesses a large number and considerable variety of larger apparatus, including the great tangent galvanometer, and the outfit of the magnetic observatory, and several Gramme and other dynamos. In the Sibley College, also, are a number of dynamos, including an Edison, a Mather, a Westinghouse alternating machine, and Weston dynamos, ranging from the smallest sizes up to a six hundred and fifty light alternating current machine, all placed in a room adjacent to the machine shop, where the very considerable power demanded can be most conveniently furnished.

A Brackett "cradle" dynamometer and a resistance coil measuring up to twenty-two hundred ohms and four amperes, and the tangent galvanometer measuring from a fraction of an ampere to two hundred and fifty amperes, supply the means of making quantitative measurements of heavy currents.

HANSEN'S MILK SEPARATOR.

THE working parts of the machine consist of: (1) The rotary vessel, A, Fig. 1, turned out of a solid ingot of mild steel, and guaranteed to work with perfect safety up to 10,000 revolutions per minute, up to which speed all the vessels are tested before leaving the works. The ordinary working speed of the vessel is, however, 6,000 revolutions per minute, so that there is ample margin for safety. (2) The short steel taper spindle,



HANSEN'S CENTRIFUGAL MILK SEPARATOR.

B, Fig. 1, fitted into the bottom of the vessel. (3) The gun metal bush, E, Fig. 1, in which the spindle revolves, and is the only bearing in the machine. (4) The adjustable, round-headed pivot, F, made of hardened steel, fitted in the bottom of the bearing, and adjusted by the steel lock nuts, G, Fig. 1. (5) The cast iron stand, D, Fig. 1, which carries the bearing. (6) The gun metal pulley, C, Fig. 1, fastened to the bottom of the vessel by screws, which forms a shield for the spindle, to prevent any damage being done thereto when the vessel is removed for cleaning purposes.

It may here be useful to explain that the vessel is adjusted for working by setting up the taper spindle, A, by means of the pivot, to a height that gives sufficient side play in the bearing, E, to enable the vessel to find a natural center when revolving, so that there is no side friction whatever; and by an ingenious and simple method of keeping the bearing, E, thoroughly and constantly lubricated, as hereafter described, the spindle is made to revolve in oil. The only point of contact, therefore, is where the spindle, B, rests on the pivot, F, a wearing surface of about $\frac{1}{8}$ in. in diameter; and the power required to drive the No. 3 machine at its ordinary working speed of 6,000 revolutions per minute may be gathered from the fact that it may be communicated through a belt of $1\frac{1}{4}$ in. ordinary lamp wick.

It might be thought that there would be a great deal of wear on so small a surface, but it would appear that there is not, and that when the vessel is adjusted, months of regular work make no appreciable difference either to the spindle or pivot, from which the makers infer that the vessel when revolving must be nearly in suspension. The mounting of the vessel on the small steel spindle, and the single bearing in which it revolves as above described, constitute the chief claim of the inventor.

The creaming capacity of the machine is regulated by the hollow pins, *a* and *b*, Fig. 1, *a* communicating with the passages in the wings, I, Fig. 1. Specially thick cream for table use, or the maximum amount of duty, as regards quantity of milk separated, is obtained by regulating the outflow of cream at *b*, Fig. 1, and of milk at *a*, Fig. 1, which is effected by the use of duplicate hollow pins, several of which are supplied with each machine, having various sized outlets into the vertical passages above mentioned. The movable wings, I, Fig. 1, are said to form an important feature of the invention. On the bottom of each is a passage, C, Fig. 1, to convey the milk to the outside of the vessel as it falls into the center piece, J, Fig. 1, through the pipe, N, Fig. 1, and on the top of one of these is the return passage, *d*, Fig. 1, through which the separated milk flows to the outlet, *c*, through the hollow pin, *a*, as before described. By the use of these wings and the ready way of removing them, as afterward described, two great difficulties are overcome, namely, (1) the necessity for the inflowing milk having to find its way through the cream and partially separated milk to the outside of the vessel, instead of being conveyed through the passages, *c*, before mentioned; and (2) that of having the outflow passage for the separated milk soldered to the top of the inside vessel, where it cannot be seen to be cleaned out, and forms corners, which collect dirt, difficult or impossible to remove. The circular trough, K, has a double passage, *f* and *g*, Fig. 1, the former for receiving the separated milk, and the latter for the cream as delivered from the machine, and conveying same into the cans placed under the respective spouts.

When the machine has finished work, the covering tins, *h*, *i*, and *j*, Fig. 1, are removed, the circular trough, K, remaining and being cleaned in its place. The wings, I, are liberated by first taking out the center piece, J, and drawn to the center of the vessel, from whence they are easily removed. The hollow pins, *a* and *b*, are also pulled out to leave the vertical passage, *e*, clear. The vessel is then left free from any projecting parts whatever, and is taken off as shown in Figs. 2 and 3, and removed with the other parts to be thoroughly cleaned by scalding.

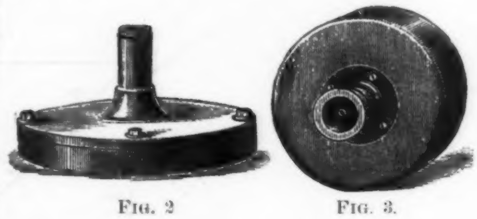


FIG. 2 FIG. 3.

The method of lubricating the bottom bearing of the machine, before referred to as being an ingenious and simple method, may now be described. The oil, which should be of good quality, though there is no necessity for any specially prepared for the purpose, is conveyed from a cup fixed to the outside of the machine casing, a little above the parts to be lubricated, through the pipe, H—Fig. 1—and up the center of the pivot, F, through a notch filed in the top of same into the bottom of holder. The revolving of the spindle, B, draws the oil from thence up a spiral groove cut in the bottom and top of the inside of the bearing, E—the middle part being recessed—into the upper holder, L, at the top of the bearing, from whence it finds its way down through the three channels, *m*, into the bottom holder, E, and so on, round and round, as before, in a constant state of circulation. The superfluous oil runs through a small outlet in the upper holder, *l*, and down the stand, D, to be collected in the receptacle formed by the flange, N. Should the oil passages in the bottom bearing and pivot require cleaning, it may be effectually done by disconnecting the outside pipe leading to the pivot, F, and pouring turpentine down the upper holders. This should be done just after the vessel is removed, when the machine has finished work.

The manufacturers direct special attention to the following points: (*a*) The vessel being fully and perfectly balanced, and not to any normal speed above which there is danger in running, or up to which it must run to separate efficiently; (*b*) the machine being entirely self-contained, and only requiring to be set level on the floor without fixing down, so that there is no necessity for any foundation; (*c*) no special attention being required to start the vessel, which will gather its speed without vibration, and may be stopped and started again with little or much milk therein; (*d*) efficient skimming at any speed, and no air bubbles, and a minimum of froth in the cream; (*e*) simplicity of construction.

The machine will be exhibited at the Smithfield Club show by the manufacturers, Messrs. Farmer, Robey, Clark & Co., Gainsborough, England.

HOLD your breath and contract your abdominal muscles is the remedy for sea-sickness suggested by an English physician, Dr. E. P. Thurston, who speaks from experience.

MICROSCOPIC PHOTOGRAPHY AT THE ALGIERS ZOOLOGICAL STATION.

HAVING for quite a long time been occupied with microscopic photography, and being the first, I believe, who has succeeded in obtaining instantaneous photographs of living animals magnified from 70 to 80 diameters, I was obliged to make an effort to put the new establishment in a state to render every service that zoology has the right to expect of the new photographic methods.

The wonderful sensitiveness of gelatino-bromide of silver plates naturally renders their manipulation very delicate, and the arrangement of the laboratory counts for much in the success of it. It is unnecessary to say that the laboratory should be able to remain for a long time in absolute darkness. Consequently, it should be provided with a double door in order to allow a person to enter and go out without inconvenience during the operations, which are sometimes lengthy, especially with hydroquinone; and the artificial ventilation should be sufficiently perfect to allow the operator to remain in the room for half an hour or more, even during the heat of summer, without experiencing fatigue. We have obtained such a ventilation at Algiers in the simplest manner by lighting a large gas burner in a draught chimney. Be it understood, the air enters and makes its exit through sinuous flues formed in the walls while in course of construction. The draught can be regulated at will.

Though it is absolutely necessary to be able to shut off all the light, it is none the less necessary to have sufficient light to enable the operator to watch the least details of the development. Like most photographers, I have for negatives absolutely given up the use of artificial light, which is often variable, and, thanks to our accumulators, I never employ anything but the electric light. The cabinet of the station is lighted by three 16-candle Swan lamps—one of them independent and designed to give the ordinary light during the night and the two others exclusively employed for the developments. These latter are placed upon the same circuit, to which can be interposed at will a half or the whole of quite a resistant rheostat. The current, thus manageable, may, by means of another commutator, be sent to a red lamp fixed to a bracket, or to a white lamp placed in a large developing lantern, having a red and yellow glass, and hermetically closed. The operator thus has at hand a means of obtaining three different degrees of light, always nearly identically the same for a given position, either upon the plate in course of development or for the other manipulations, such as washing, etc. It is thus possible to judge perfectly of the coming of the image. The laboratory is provided with two water cocks for washing and with two gas cocks for heating baths, drying in stoves, etc. But I must not dwell upon the general installation any more than upon the ordinary photographic apparatus, and I come at once to the microscopic photographic apparatus, which was constructed for the station after my drawings, and which represents a new type.

Here, again, the first question to be solved was that of illumination, which must be so much the stronger in proportion as the magnifications to be obtained are greater—the luminous intensity, as well known, decreasing with the square of the magnification.

Although the 32-candle incandescent lamps with which the station is also provided suffice for slight magnifications and prolonged exposures, their light is not strong enough for instantaneous photographs or great magnifications. In these cases recourse has to be had to an arc lamp in cloudy weather. The terminals of this are seen at B, in Fig. 1. Since, then, our battery of accumulators would no longer suffice, and the entire force of the dynamo is requisite, it is necessary to set the motor running for every operation.

Even had it not been merely a question of economy, I still should have had to think of using the light of the sun as much as possible. The isolation of the station, curved in the form of a terrace, peculiarly favored, moreover, the installation of a heliostat, and, as there is but one polar heliostat capable of sending a ray always in one direction, whatever be the position of the sun, that is the type that I decided upon. As well known, the direction of the ray reflected by these instruments is necessarily that of the axis of the world. As I had, fortunately, before the beginning of the work, determined the exact point to be lighted it was possible for me to have the structure so arranged that nothing should impede the passage of the ray, although it had to traverse the house in a doubly oblique direction and for a distance of 30 feet. Toward the center of such distance, on the floor of the top room, may be placed a slide supporting an alum box and a lens of slight curvature whose focus is on the mirror of the photographic microscope. The solar ray enters the laboratory in which the instrument is placed almost through the center of the floor, and is arrested there by a shutter which is maneuvered by means of the rubber bulb, V, placed alongside of the microscope (Fig. 1).

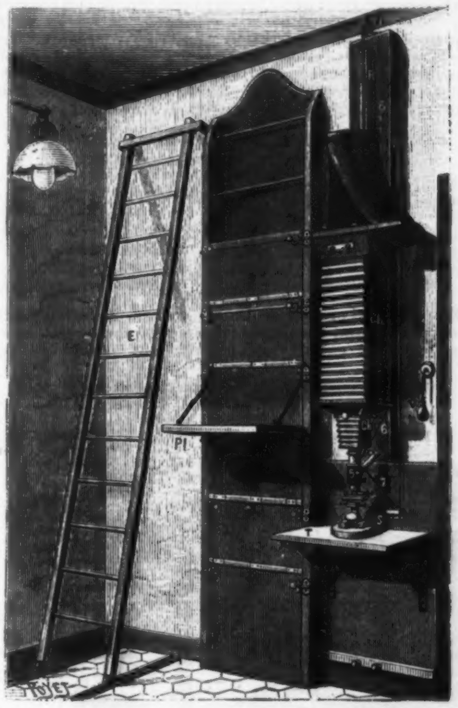


FIG. 1.—GENERAL VIEW OF THE PHOTOGRAPHIC APPARATUS OF THE ALGIERS STATION.

Ch, camera; R, rail upon which it slides; *Po*, guide pulley for the cord of the counterpoise; *Ch'*, coupling sleeve; S, revolving sector; B, electric terminals.

Fig. 2, Nos. 1, 2, 3, 4, and 5, and its legend gives a sufficient idea of the arrangement of the apparatus. In order to use the latter, we begin by putting the microscope upon the revolving sector (No. 3), where its place is found accurately marked, and, after opening the shutter, 8, by pulling a button, we fix, through a coupling ring, an ordinary microscopic eyepiece in the vertical tube, and then focus the object exactly as with an ordinary microscope. Next, we remove this eyepiece, and bring the sector into the position in which it is seen in Fig. 2, No. 3, where it is fixed by means of a bolt, *v*. The vertical tube is then exactly in the axis of the camera, and the mirror, *m*, is on the direction line of the ray sent by the heliostat. Moreover, verticalness is assured, the table, T (Fig. 1), being mounted upon three adjusting screws. The sleeve, *Ch*, of the camera is then connected with the vertical tube, and the transmissions, 6 and 7, are put in place. All this is done in an instant. The camera, sliding upon a single graduated rail, R (Fig. 1), whose section is in the form of a dovetail, is then extended to the desired length, and fixed by a simple pressure screw, its weight being balanced. In order to do the focusing, the operator ascends the ladder, E, and lets down one of the folding foot-boards, as shown at P *l* in Fig. 1. Whatever be the height to which he ascends, he can, through the rod, 6, act upon the micrometer screw of the microscope, and this is the mode of regulation usually employed for low power objectives. For objectives of high power, on the contrary, I think, with Woodward, that it is better not to change the position for which they have been constructed, and the focusing is done by means of the transmission, 7, which displaces a divergent lens in the interior of the tube.

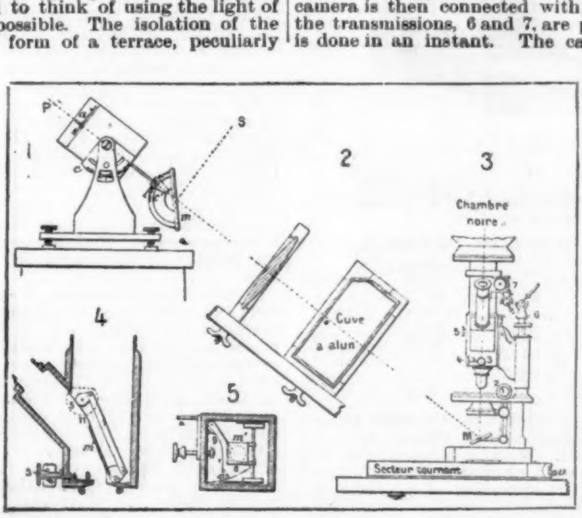


FIG. 2.

1, 2, and 3, relative position of the instruments. No. 1, heliostat; *a*, needle carrying a pinnule and screen to mark the time; *c*, circle for position in latitude; *c'*, circle for variations in the declinations of the sun. The mirror, *m*, is represented at the position of the equinox. The ray, reflected in the direction, P M, of the earth's axis, traverses a lens and alarm box (2), and falls upon the mirror, *m*, of the microscope (3), which is represented in vertical section (4) and plan (5). 12, milled heads of the screw of the microscope stage; 3, button for maneuvering the shutter; 4, shutter bolt; 5, button for maneuvering the mirror, *m'*; 6 and 7, apparatus for focusing; 9, spring for closing the shutter; 8 and 10, pedal for keeping the shutter open; 11, screen surmounting the mirror; V, bolt for arresting the revolving sector.

The two transmissions, 6 and 7 (Figs. 1 and 2), which are constructed upon the same principle, consist of long vertical rods which, through pinions that retard the motion, actuate slender rods that are provided at each extremity with a gimbal joint. The transmission is slow and the focusing is accurate. The focusing is done, as may be desired, either upon ground glass or upon a screen that is viewed through an aperture in the side of the camera.

After focusing, the shutter, 8, is closed, and is opened again only during the time of the exposure. This is all the maneuvering of the instrument for an immovable object.

When it is a question of a living animal that it is necessary to be able to watch, the operation is as follows. The object is brought to the center of the field by means of the milled heads, 1 and 2, of the movable stage, and the luminous fascicle is sent into the lateral tube, which carries an eyepiece provided with concentric circles. This is effected by means of the screw, 5, which, through the intermedium of a rod, controls the motion of a black glass, *m'* (Fig. 2, No. 4). This glass is provided with regulating screws at right angles, in order to render the centering of the images exactly the same in the vertical tube and the camera. It should be understood that the lateral tube is necessarily provided with converging lenses in order to render it possible to observe through the eyepiece as in an ordinary microscope, and, naturally, the lenses are of different power according to the length given to the camera.

The milled head, 5, is placed somewhat high in order that the operator's hand may not cast a shadow upon the objects when the latter are illuminated by reflection. It is possible, at will, through the milled head, 4, to render the shutter, 8, dependent upon or independent of the mirror, *m'*, so that the motion of the milled head, 5, shall raise the mirror and leave the shutter open, or, on the contrary, at once close the latter, and thus send an instantaneous flash to the sensitized plate.

The apparatus carries the Abbey condenser, provided with an iris diaphragm, and is capable of operating with polarized or simple light, as may be desired. The micrometer screw is provided with a dial for photographs with successive planes.

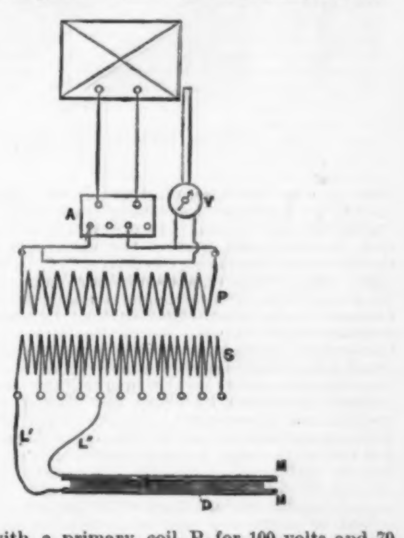
Finally the large camera, after the microscope has been detached, may, in place of the coupling sleeve, C *h*, receive an ordinary photographic objective, and thus constitute the vertical apparatus indispensable in a laboratory of this kind for photographing animal preparations and the upper surface of floating animals.

As a last advantage of this installation, I shall remark that the whole affair, after the ladder, E, has been shoved up against the wall and the foot board folded, occupies but an insignificant space, and in nowise interferes with the other arrangements of the laboratory, and this, as well known, is far from being the case with the majority of the apparatus hitherto employed.—*Dr. C. Vignier, in La Nature.*

A 10,000 VOLT TRANSFORMER.

THE usual tests of insulation consisting only of a measurement of the insulation resistance afford very little guarantee, especially in the case of electric light cables, for the working strength of the insulation, seeing that the test is usually made by means of laboratory batteries having a comparatively low E.M.F.

At the "Menier" electric cable works in Paris-Grenelle an alternating current transformer, made by Messrs. Ganz & Co., of Buda-Pesth, has been used since March, 1888, for the purpose of testing cable insulation as well as any dielectric. This transformer is constructed with a primary coil, P, for 100 volts and 70 amperes, and a secondary, S, for 10,000 volts and 0·07 ampere, the ratio of transformation being 1 : 100.



The secondary coil is divided into ten divisions, the ends of which are led to metal contact pieces with conical holes. By means of two plugs and two flexible leads, L' L'', the dielectric to be tested can be subjected to a difference of potential of from 1,000 up to 10,000 volts, and its behavior observed.

In the primary circuit there is, as well as the generator, a double pole switch, A, in order to cut off the primary circuit entirely before altering the secondary difference of potential by shifting plugs. A Cardew voltmeter indicates for the control of the primary potential.

Concerning the construction of the transformer, it may be mentioned that the primary and secondary coils, as well as the divisions of the secondary, are carefully insulated from one another with ebonite. The metal pieces forming the terminals of the secondary divisions are mounted on high ebonite supports, the

metal plugs being also furnished with long handles of the same material.

The transformer, together with the terminals, are mounted on a strong base board, on which there is also a double pole switch with porcelain base and handle.

This method of testing the insulation of cables affords a far better guarantee for their safe working in actual use than that of testing by measuring the insulation resistance with a comparatively low E.M.F.—*Electrical Review.*

MAGNETIC SEPARATOR.

AFTER a series of experiments conducted over a considerable period, T. A. Edison has developed the magnetic separator invented by him into a practical machine. The principle upon which it is based is extremely simple, consisting as it does of deflecting by a powerful magnet those particles in a mixture of ore and gangue which are magnetic in their fall by its field. The quartz or other gangue falling by the magnet are not affected by its attraction. The particles of magnetite or of magnetic oxide are diverted from the vertical sufficiently to reach the floor at a point considerably removed from that which they would attain in a free fall. Given, then, a thin sheet of ore dropping by a broad magnet, the gangue accumulates immediately below the orifice from which the sheet fell, while the magnetic particles of the ore will be found separated from it. The accompanying engraving, from a photograph of the machine now in place at Edison's laboratory, at Llewellyn Park, N. J., will clearly show how this principle has been carried out. We may state, however, that since the photograph was taken a number of minor changes have been made without affecting the general design. The ore, which is first crushed and screened (this part of the apparatus not being shown in our engraving), is delivered by a bucket elevator into the hopper, shown in part in our engraving. In the bottom of this hopper is a long slit, which can be closed by a sharp-edged casting, balanced by the counterweight shown. Below the hopper is mounted the magnet, a casting weighing three tons in this case, around which are wrapped a series of coils of wire. To regulate the power of the magnet, the arrangement provided is shown, by which any desired number of the coils can be arranged in multiple arc or in series. In the apparatus as now modified, this arrangement is put out of the way, being mounted on the top of the magnet instead of at the side. A dynamo furnishes a current of 25 to 30 amperes and 110 volts. Since our engraving was made, a hand wheel and screw have been added to move the magnet forward or backward, as needed, scales being provided to record its exact position. In order to separate more sharply the gangue from the ore as it accumulates on either side of the projection to the floor of the line of the slot in the hopper, a slender, movable partition is placed in position on the floor. Now, there exists a narrow zone within which those particles collect which are only very slightly deflected particles of gangue, to which a minute speck of magnetite may adhere. In order to collect this material separately, the partition is made in the form of a narrow box, which has been facetiously termed the "mugwump." Lately a scale has been attached to the floor and to the wall, in order to facilitate the recording of the exact position of the "mugwump." Immediately above the magnet is a pipe with a series of perforations, through which jets of air, supplied by a fan, can be projected against the following sheet of material to be concentrated should it be considered desirable to remove the dust from the ore.

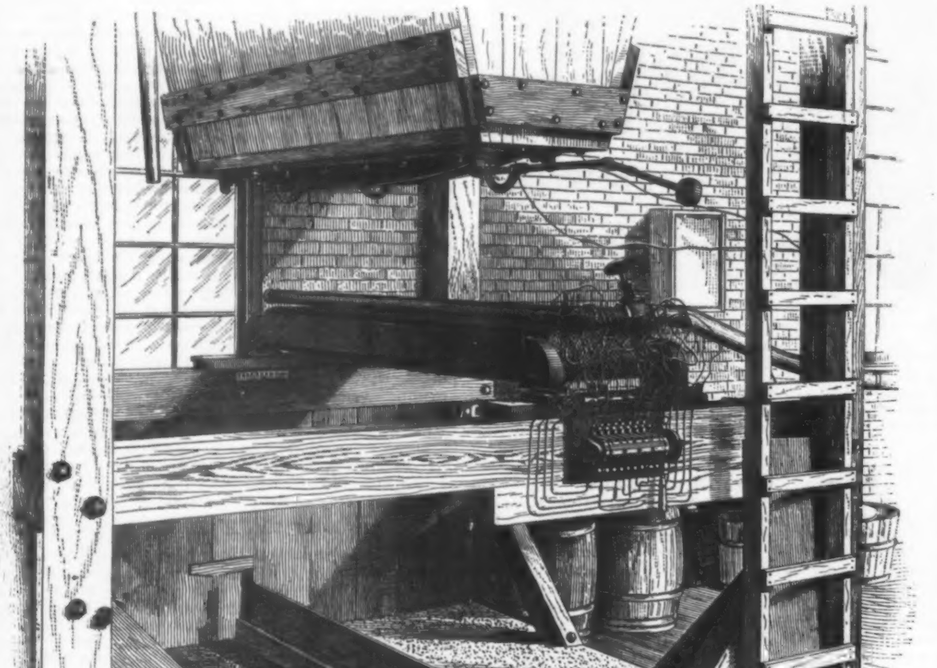
Experiments have been made on various ores with the Edison separator, among those treated being ores from the Port Henry and Chateaugay mines, of the Lake Champlain district, and from the Croton mines in Putnam County, N. Y. The results of the separation have not been checked in every case by chemical analysis, and in some instances the latter is not completed. We are in a position, through the courtesy of John Birkinbine, of Philadelphia, consulting engineer of T. A. Edison, to place the following data before the readers of the *Iron Age*.

Witherbees, Sherman & Co., of Port Henry, N. Y., have had a number of separations made of two classes of ore which their mines produce, viz., the "New Bed Lean" and the "Old Bed Ore." The former is within the Bessemer limit as to phosphorus, but it is a part of the material mined with the richer ore of the vein. The object of the separation would be to remove the silica, which is present in so large a quantity as to prevent the advantageous shipment of the ore to the furnaces. The following analyses show that the result is satisfactory, so far as the quality is concerned:

Separation of New Bed Lean Ore, Port Henry.

		Crude ore.	Concentrates.	Tailings.
A. Crushed to 20 mesh.	Iron...	53·20	69·90	7·67
	Phos..	0·03	0·01	0·08
B. Crushed to 10 mesh	Iron...	51·60	70·00	7·80
	Phos..	0·025	0·018	0·41
C. Above 10 mesh.....	Iron...	52·20	66·80	18·70
	Phos..	0·032	0·013	0.085

The Old Bed ore is rich in iron, but it is also high in phosphorus, and the experiments were made to determine to what extent phosphorus can be removed by magnetic separation, that element being present in the ore in the form of crystals of apatite.



THE EDISON MAGNETIC IRON ORE SEPARATOR.

Separation of Old Bed Ore, Port Henry.

	Crude ore.	Concentrates.	Tailings.
Iron.....................	59·5	69·15	7·10
Phosphorus.............	1·77	0·41	11·06
Iron.....................	62·00	70·90	9·25
Phosphorus.............	1·46	0·18	10·54
Iron.....................	64·20	71·20	9·00
Phosphorus.............	1·39	0·31	11·57

It will be observed that while a considerable proportion of the phosphorus has been eliminated, it is still above the Bessemer limit. When it is considered how quickly a few stray crystals of apatite will affect the result, the delicacy of the operation of removing the phosphorus will be appreciated.

The following result was obtained in a test of ore from the waste dump of the Croton mine, Putnam County, N. Y.:

Separation of Croton Ore.

	Crude ore.	Concentrates.	Tailings.
Iron..................	37·97	64·72	11·04
Phosphorus	0·38	0·10	0·97

So far as we know, the tests thus far have not been carried out by weighing concentrates and tailings produced by running through large quantities. It may be well, however, to call attention to the fact that a high percentage of iron in the tailings does not imply a heavy loss of metal. A simple computation will prove this. Thus, in the case of sample A of Port Henry, New Bed Lean, if there were no waste, the loss of iron represented by tailings carrying 7·67 per cent. would be only 3·86 pounds in 100 pounds of the metal contained in the original ore.

Mr. Edison has not, however, confined himself to magnetites. He has experimented with roasting non-magnetic ores, in order to first convert its oxide into the magnetic oxide, and then putting it through his machine. The possibilities of handling titaniferous ores have also been taken into consideration. One of his machines is now being put up in Michigan, and others have been ordered.—*Iron Age.*

[Continued from SUPPLEMENT, No. 679, page 10847.]

THE GASES OF THE BLOOD.*

By Prof. JOHN GRAY MCKENDRICK, M.D.

II.

IN 1809 the subject of aquatic breathing was investigated with great care by Provencal and Humboldt. They collected and analyzed the gases of water before and after fishes had lived in it for a certain time, and showed that oxygen was consumed and carbonic acid produced by these creatures.

We have now seen how gradually knowledge was arrived at as to the respiratory exchanges. At the beginning of the present century it was recognized that expired air had lost oxygen, gained carbonic acid and aqueous vapor, and had become hotter. Since then many researches have been carried on to determine with accuracy the quantities of these substances. In all of these, as shown in these diagrams, † the method followed has been to draw through a chamber containing the animal a steady, constant stream of air, the quantity and composition of which is known.

Thus, suppose a certain quantity of dry air, free from carbonic acid, and consisting only of oxygen and nitrogen, is passed through such a chamber. In the chamber some of the oxygen is consumed, and a certain amount of carbonic acid and of aqueous vapor is given up by the animal. The air is drawn onward through bulbs or glass tubes containing substances, such as baryta water, to absorb the carbonic acid, and chloride of calcium or sulphuric acid, to absorb the aqueous vapor. It is evident that the increased weight of these bulbs and tubes, after the experiment has gone on for some time, will give the amounts of carbonic acid and aqueous vapor formed. Thus Andral and Gavarret in 1843, Vierordt in 1845, Regnault and Reiset in 1849, Von Pettenkofer in 1860, and Angus Smith in 1862, determined the quantities both by experiments on animals and on human beings.

The results are—first, the expired air, at its own temperature, is saturated with aqueous vapor; secondly, the expired air is less in volume than the inspired air to the extent of about one-fortieth of the volume of the latter; thirdly, the expired air contains about 4 per cent. more carbonic acid and from 4 to 5 per cent. less oxygen than inspired air; fourthly, the total daily excretion of carbonic acid by an average man amounts to 800 grammes in weight and 406 liters in bulk. This amount of carbonic acid represents 218·1 grammes of carbon and 581·9 grammes of oxygen. The amount of oxygen, however, actually consumed is about 700 grammes; so that nearly 120 grammes of oxygen absorbed are not returned by the lungs, but disappear in the body. It must be remembered, however, that carbonic acid escapes by the skin and other channels. These figures may be taken as averages, and are subject to wide variations depending on nutritional changes.

There is, however, another side to the problem of respiration—namely, a consideration of the chemical changes involved in the process.

According to Lavoisier, respiration was really a slow combustion of carbon and of hydrogen. The air supplied the oxygen, and the blood the combustible materials. The great French chemist, however, did not entirely commit himself to the opinion that the combustion occurred only in the lungs. He says that a portion of the carbonic acid may be formed immediately in the lung, or in the blood vessels throughout the body, by combination of the oxygen of the air with the carbon of the blood. Lavoisier's opinions were understood correctly by only a few of his contemporaries, and a notion prevailed that, according to him, combustion occurred only in the lungs, and that the changes in these organs were the main sources of animal heat. Such a notion, however, was contrary to the opinion of the great mathematician Lagrange, announced in 1791, a few years after the first publication of Lavoisier's on respiration. Lagrange saw that, if heat were produced in the lungs alone, the temperature of these organs might become so high as to destroy them; and he therefore supposed that the oxygen is simply dissolved in the blood, and in that fluid combined with carbon and hydrogen, forming carbonic acid and aqueous vapor, which were then set free in the lungs. It will be observed that this opinion of Lagrange in 1791 was practically the same as that stated by Lavoisier in 1789.

Now, if the production of carbonic acid in a given time depended upon the amount of oxygen supplied in the same time, these views of Lavoisier and Lagrange would be correct; but Spallanzani had shown that certain animals confined in an atmosphere of nitrogen or of hydrogen exhaled carbonic acid to almost as great an extent as if they had breathed air. He was therefore obliged to say that carbonic acid previously existed in the body, and that its appearance could not be accounted for by the union of oxygen with the carbon of the blood. Spallanzani therefore thought that in the lung there was simply an exhalation of carbonic acid and an absorption of oxygen. These views were supported by the experiments of W. Edwards, published in 1824. Edwards showed that animals in an atmosphere of hydrogen produced an amount of carbonic acid not to be accounted for by any oxygen supposed to exist free in the body. In 1830, Collard de Martigny performed many similar experiments, and stated that carbonic acid was secreted in the capillaries and excreted by the lungs. This opinion was supported by Johannes Muller, who repeated the experiments of Spallanzani.

It might thus be said that two theories of respiration were before physiologists—the one, that combustion occurred in the lungs or venous blood, furnishing carbonic acid and aqueous vapor, which were exhaled by the lungs; the other, that there was no such combustion, but that oxygen was absorbed by the lungs and carried to the tissues, while in these carbonic acid was

* Address to the British Medical Association at its annual meeting at Glasgow. Delivered on August 10 in the Natural Philosophy class-room, University of Glasgow, by John Gray McKendrick, M.D., LL.D., F.R.SS.L. and E., F.R.C.P.E., Professor of the Institutes of Medicine in the University of Glasgow.—*Nature.*

† Diagrams exhibited on wall.

secreted, absorbed by the blood, carried to the lungs, and there exhaled. Some writers, soon after Lavoisier, misunderstood, as I have already stated, the opinions of that distinguished man, and taught that in the lungs themselves there was a separation of carbon, which united immediately with the oxygen to form carbonic acid. But this was really not Lavoisier's opinion; and we have to do, therefore, with two theories, which have been well named the theory of combustion and the theory of secretion.

The difficulty felt by the older physiologists in accepting the secretion theory was the absence of proof of the existence of free oxygen and carbonic acid in the blood. This difficulty also met those who rejected the notion of combustion occurring in the lungs, and substituted for it the idea that it really occurred in the blood throughout the body, because if this were true, free gases ought to be found in the blood. Consequently, so long as physiologists had no definite knowledge regarding gases in the blood, the combustion theory, in the most limited sense, held its ground. This theory, although fruitful of many ideas regarding respiration and animal heat, was abandoned in consequence of the evidence afforded by two lines of inquiry—namely, researches regarding the gases of the blood and researches as to the relative temperature of the blood in the right and left cavities of the heart.

Let me first direct your attention to the gradual development of our knowledge regarding the gases of the blood. The remarkable change in the color of the blood when it is exposed to, or shaken up with, air was observed so long ago as in 1665 by Fracassati, and is also alluded to by Lower (1631–91), Mayow, Cigna (1773), and Hewson (1774); but Priestley was the first to show that the increased redness was due to the action of the oxygen of the air, and that the blood became purple when agitated with carbonic acid, hydrogen, and nitrogen. The presence of gas in the blood was first observed about 1672 by Mayow. I find in a paper of Leeuwenhoek (1632–1723), entitled "The Author's Experiments and Observations respecting the Quantity of Air contained in Water and other Fluids," published in 1674, a description of a method devised by this ingenious man for detecting the existence of air in certain fluids, and among them in the blood. It consisted of a kind of syringe, by which he was able to produce a partial vacuum. He then observed bubbles of gas to escape, and he estimated, in the case of human blood, that the air in the blood amounted to $\frac{1}{1500}$ or $\frac{1}{1800}$ part of the volume of the blood. He argues, from this interesting observation, against one of the prevalent medical theories of the time, that various diseases were caused by fermentations in the blood. How, said he, was such a theory consistent with the existence of so small a quantity of gas? He made the mistake, from the inefficiency of his apparatus, of stating that blood, when it issues from the veins, contains no air.

Gas was also obtained from the blood in 1799 by Sir Humphry Davy, in 1814 by Vogel, 1818 by Brand, in 1833 by Hoffmann, and in 1835 by Stevens. On the other hand, John Davy, Bergmann, Johannes Muller, Mitscherlich, Gmelin, and Tiedemann failed in obtaining any gas. The first group of observers, either by heating the blood, or by allowing it to flow into a vacuum, or by passing through it a stream of hydrogen, obtained small quantities of carbonic acid. Sir Humphry Davy was the first to collect a small quantity of oxygen from the blood. John Davy, by an erroneous method of investigation, was led, in 1828, to deny that the blood either absorbed oxygen or gave off carbonic acid. He was shown to be wrong, in 1830, by Christison, who devised a simple method of demonstrating the fact.

So long as the evidence in favor of the existence of gases in the blood was so uncertain, the combustion theory of respiration held its own. At last, in 1836, appeared the researches of Heinrich Gustav Magnus, latterly Professor of Physics and Technology in the University of Berlin. He first attempted to drive off carbonic acid from the blood by a stream of hydrogen, and thus obtained as much as 34 cubic centimeters of carbonic acid from 62·9 cubic centimeters of blood. He then devised a mercurial air pump, by which it was possible to exhaust a receiver to a much greater extent than could be done by the ordinary air pump. When blood was introduced into such a vacuum, considerable quantities of carbonic acid, oxygen, and nitrogen were obtained. This research marks an epoch in physiological discovery, as it threw a new light on the function of respiration by demonstrating the existence of gases in the blood.

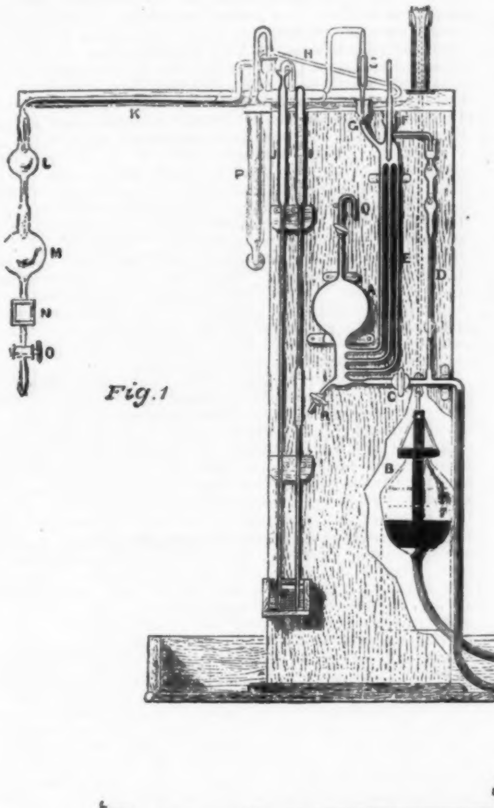


Fig.1

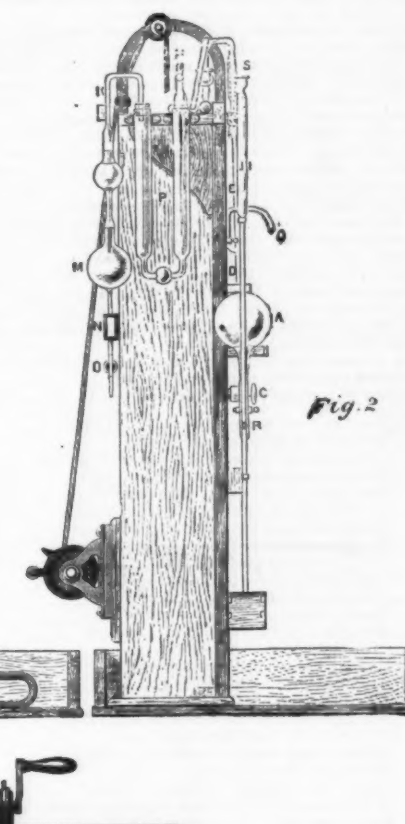


Fig.2

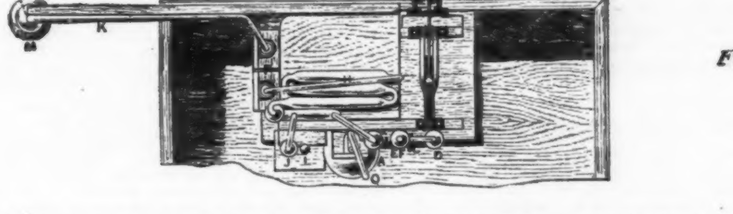


Fig.3

FIGS. 1, 2, and 3.—Views of a gas pump constructed for the purpose of extracting and collecting the gases of the blood and suitable for the physiological lecture table. These views have been correctly drawn on the scale of 1 to 10 by my friend the Rev. A. Hanns Geyer.* Fig. 1, front view: A, glass bulb connected by horizontal glass tube with bulb, B; this tube guarded by stopcock, C. By elevating B, A is filled with mercury, stopcock of delivery tube, Q, is closed, and B is lowered; A is thus exhausted and air is drawn into it by tubes, E, connected by G with drying apparatus and blood chamber. I, permanent barometer; J, barometer gauge tube connected with part of instrument to be exhausted. Both I and J dip into mercury trough seen below; S, a glass float to prevent mercury from running into drying apparatus when B is raised. After A and the drying apparatus and the blood chamber have been well exhausted, B is raised and mercury may be allowed to pass up D, and then the apparatus acts as a Sprengel pump by the three tubes, E. Fig. 2, side view of apparatus: same references. Fig. 3, drying apparatus, placed on a shelf at the top of the pump, consisting of H, tubes containing solid phosphoric acid, and U tube, P, seen in Fig. 2, containing sulphuric acid. The tube, K, passes to receiver. In the drawing it is seen to be connected with an apparatus suitable for projecting the spectrum of oxy-hæmoglobin by lime or electric light on screen; then exhausting the blood of oxygen and showing the spectrum of reduced hæmoglobin. L and M, froth chambers with traps; N, parallel-sided chamber for blood; O, stopcock. The whole pump is modeled on one I obtained about ten years ago from Messrs. Mawson and Swan, of Newcastle, but it has been much altered and added to, so as make it suitable for physiological demonstration. It is evident that the gases can be readily obtained for analysis by driving out of A, by delivery tube, Q. A rough demonstration of the gases can be made in from five to ten minutes.

* The pump can be obtained from Mr. W. Potter, glass blower, Physical and Physiological Laboratories, University of Glasgow, who will give information as to cost.

In order to appreciate the value of this evidence, and the method employed, let me direct your attention to the laws regulating the diffusion of gases. As a mass of gaseous matter has no independent form, like that of a solid body, nor a fixed volume like that of a liquid, but consists of an enormous number of molecules which, in consequence of their mutual repulsions, endeavor more and more to separate from each other, it is easy to see that if two masses of gas are brought into contact, they will mix, that is, their molecules will interpenetrate, until a mixture is formed containing an equal number of the molecules of each gas. The force by which the molecules repel each other, and by which they exercise pressure in all directions, is known as the pressure or tension of the gas. It is evident that the greater the number of gas molecules in a given space, the greater will be the tension of the gas, and from this it follows that the tension of a gas is in the inverse proportion to its volume (this is known as Boyle's law). Suppose now that two gases are separated by a porous partition; the two gases will mix, and the rapidity of the diffusion will vary according to the specific weight of the gases. Thus light gases, like hydrogen or coal gas, will diffuse more quickly than air, or chlorine, or carbonic acid.

It is important also to note the laws regulating the absorption of gases by fluids. If we allow a little water to come into contact with ammonia gas above mercury, the gas is rapidly absorbed by the water (1 volume of water absorbs 730 volumes NH_3), all the gas above disappears, and in consequence of this the pressure of outer air drives up the mercury in the tube. The higher the temperature of the fluid, the less gas it absorbs. At the boiling point of the fluid its absorption is $= 0$, because at that temperature the fluid itself changes into gas. The power of absorption of different fluids for the same gas and the absorptive power of the same fluid for different gases fluctuate between wide limits. Bunsen defined the coefficient of absorption of a fluid for a gas as that number which represents the volume of gas (reduced to 0° and 760 mm. barometric pressure) which is taken up by one volume of the fluid. Thus 1 volume of distilled water takes up the following volumes:

Temp. Cent.	N.	O.	CO_2.	Air.
0°	0·02	0·041	1·797	0·025
5	0·018	0·036	1·5	0·022
15	0·015	0·03	1·002	0·018
37	—	0·02	0·569	—

Again, 1 volume of distilled water at 0° C. absorbs 0·00193 volume of hydrogen, while it can take up no less than 1,180 volumes of ammonia; again, 1 volume of water at 0° C. absorbs only 0·2563 volume of olefiant gas, but one volume of alcohol, at the same temperature, will take up as much as 3·595 volumes. The volume of gas absorbed is independent of the pressure, and the same volume of gas is always absorbed, whatever the pressure may happen to be. But as according to Boyle's law the density of a gas, or in other words the number of molecules in a given space, is in proportion to the pressure, and as the weight is equal to the product of the volume and the density, so while the volume absorbed always remains the same, the quantity or weight of the absorbed gas rises and falls in proportion to the pressure (this is the law of Dalton and Henry). It therefore follows that a gas is to be considered as physically absorbed by a fluid, if it separates from it, not in volumes, but in quantities, the weights of which are in proportion to the fall of pressure.

When two or more gases form an atmosphere above a fluid, the absorption takes place in proportion to the pressure which each of the constituents of the mixture would exercise if it were alone in the space occupied by the mixture of gases, because, according to Dalton's law, one gas does not exercise any pressure on another gas intermingled with it, but a space filled with one gas must be considered, so far as a second gas is concerned, as a space containing no gas, or, in other words, a vacuum. This pressure which determines the absorption of the constituents of a gaseous mixture is termed, according to Bunsen, the partial pressure of the gas. The partial pressure of each single gas in a mixture of gases depends, then, on the volume of the gas in question in the mixture. Suppose atmospheric air to be under a pressure of 760 mm. of mercury, then, as the air consists of 21 volumes per cent. of O and 79 volumes per cent. of N, $\frac{760 \times 21}{100} = 159·6$ mm. of mercury, will be the partial pressure under which the oxygen gas is absorbed, while the absorption of nitrogen will take place under a pressure of $\frac{760 \times 79}{100} = 600$ mm. of mercury.

Suppose, again, that above the fluid containing a gas, say carbonic acid, which has been absorbed, there is an atmosphere of another gas, say atmospheric air, then as carbonic acid exists in the air only in traces, its tension is equal to zero, and carbonic acid will escape from the fluid until the difference of tension between the carbonic acid in the water and the carbonic acid in the air above it has been balanced—that is, until the carbonic acid which has escaped into the air has reached a tension equal to that of the gas still absorbed by the fluid. By the phrase "tension of the gas in a fluid" is understood the partial pressure in millimeters of mercury which the gas in question has to exercise in the atmosphere, when no diffusion between the gas in the fluid and the gas in the atmosphere takes place.

The method followed by Magnus will now be understood. By allowing the blood to flow into an exhausted receiver surrounded by hot water, gases were set free. These were found to be oxygen, carbonic acid, and nitrogen. He further made the important observation that both arterial and venous blood contained the gases, the difference being that in arterial blood there was more oxygen and less carbonic acid than in venous blood. Magnus concluded that the gases were simply dissolved in the blood and that respiration was a simple process of diffusion, carbonic acid passing out and oxygen passing in, according to the law of pressures I have just explained.

Let us apply the explanation of Magnus to what occurs in pulmonary respiration. Venous blood, containing a certain amount of carbonic acid at the temperature of the blood and under a certain pressure, is brought to the capillaries, which are distributed on the walls of the air vesicles in the lungs. In these air vesicles we have an atmosphere at a certain temperature and subject to a certain pressure. Setting temperature aside, as it may be assumed to be the same in the blood and in the air cells, let us consider the question of pressure. If the pressure of the carbonic acid in the blood be greater than that of the carbonic acid in the air cells, carbonic acid will escape until an equilibrium is established between the pressure of the gas in the blood and the pressure of the gas in the air cells. Again, if the pressure or tension of the oxygen in the air cells be greater than that of the oxygen in the venous blood, oxygen will be absorbed until the tensions become equal. This theory has no doubt the merit of simplicity, but it will be observed that it depends entirely on the assumption that the gases are simply dissolved in the blood. It was pointed out by Liebig that, according to the experiments of Regnault and Reiset, animals used the same amount of oxygen

when breathing an atmosphere composed of that gas alone as when they breathed ordinary air, and that the vital processes are not much affected by breathing the atmosphere of high altitudes where the amount of oxygen taken in is only about two-thirds of that existing at the sea level. It was also shown at a much later date, by Ludwig and W. Muller, that animals breathing in a confined space of air will use up the whole of the oxygen in the space, and it is clear that as the oxygen is used up, the partial pressure of the oxygen remaining must be steadily falling. Liebig urged the view that the gases were not simply dissolved in the blood, but existed in a state of loose chemical combination which could be dissolved by the diminished pressure in the vacuum or by the action of other gases. He also pointed out the necessity of accurately determining the coefficient of absorption of blood for the gases—that is the amount absorbed under a pressure of 760 mm. of mercury by one volume of the gas at the temperature of the observation. The next important observations were those of Fernet, published in 1855 and 1857. He expelled the greater part of the gas of the blood (dog) by passing through it a stream of hydrogen and then submitting it to the action of the air pump. He then introduced into the apparatus the gas under a given pressure, the absorption coefficient of which he had to determine. He then estimated the amount of gas absorbed, under different pressures, and found in the case of oxygen that the amount absorbed with gradually decreasing increments of pressure was greater than what would have been the case had it been in accordance with Dalton's law of pressures. The oxygen was not then simply dissolved in the blood. Further, Fernet arrived at the conclusion that the greater portion of the oxygen was in a state of combination, while a small amount was simply dissolved according to Dalton's law.

It is evident, then, that while the amount of oxygen absorbed varies with the pressure, it does not do so according to Dalton's law. The amount decreases slowly with pressures below atmospheric pressure, and it increases very rapidly with pressures above it. It is when the pressure in the vacuum is as low as one-thirtieth of an atmosphere that the oxygen is given up, and this will be about the pressure of the aqueous vapor in the apparatus at the temperature of the room when the experiment is made. The view that something in the blood is chemically united to the oxygen is strengthened by the fact that serum does not absorb much more oxygen than water can absorb, so that blood at a temperature of 30° C. would contain only about 2 volumes per cent. of oxygen gas were the latter simply dissolved in the fluid. It can also be shown that defibrinated blood takes up oxygen independently of the pressure, and that the quantity of oxygen taken up by defibrinated blood is about equal to the quantity absorbed by a solution of pure hæmoglobin containing as much of that substance as exists in the same volume of blood.

By similar experiments made with carbonic acid, Fernet determined that the greater portion of it was in a state of loose chemical combination, while a small amount was simply dissolved according to the law of pressures. Experiments with blood serum showed similar results as regards carbonic acid, with the difference that the coefficient of absorption for oxygen was much less than with ordinary blood. He therefore concluded that nearly the whole of the carbonic acid was chemically retained in the fluid of the blood, while nearly the whole of the oxygen was combined with the red blood corpuscles. He then proceeded to investigate whether or not the three principal salts of the blood, carbonate of soda, phosphate of soda, and chloride of sodium, in any way influenced the absorption coefficient of carbonic acid. He found (1) that the addition of these salts to distilled water in the proportion in which they exist in the serum slightly diminishes the absorption coefficient; (2) that chloride of sodium has no influence on the absorption coefficient; (3) that carbonic acid combines with the carbonate and phosphate of soda.

In the same year (1855) Lothar Meyer published the results of a series of researches of the same nature. Under the direction of Bunsen, the blood was diluted with ten times its bulk of water, and the gases were collected by boiling the liquid *in vacuo* at a very gentle heat; a certain amount of gas was thus obtained. He also found that blood absorbs a much larger quantity of carbonic acid than pure water at the same temperature, and stated that when blood was exposed to oxygen at various pressures, the quantity of that gas taken up might be regarded as consisting of two portions, one following Dalton's law and the other independent of it.

Further researches of a similar kind have been carried out by Setschenow, Ludwig, Alexander Schmidt, Bert, Pfluger, and others, and ingenious methods of collecting and of analyzing the gases have been devised. To Prof. Pfluger and his pupils, in particular, are we indebted for the most complete series of gas analyses on record. The result has been to enable us to give the average composition of the gases of the blood as follows. From 100 volumes of dog's blood there may be obtained:

	Oxygen.	Carbonic Acid.	Nitrogen.
Arterial..	18·4 to 22·6, mean 20	30 to 40	1·8 to 2
Venous...	Mean 11·9	43 to 48	1·8 to 2

The gases being measured at 0° C. and 760 mm. pressure. The venous blood of many organs may contain less than 11·9 per cent. of carbonic acid, and the blood of asphyxia may contain as little as 1 volume per cent. It is clear, then, that the gases of the blood do not exist in a state of simple solution, but that they are largely combined with certain constituents of the blood. Take, for example, the case of oxygen. Berzelius showed long ago that 100 volumes of water will absorb, at a given temperature and pressure, 2·9 volumes of oxygen; while, in the same circumstances, 100 volumes of serum will absorb 3·1 volumes, and 100 volumes of blood will absorb 9·6 volumes. Something in the blood must have the power of taking up a large amount of oxygen.

(*To be continued.*)

THERE is but very little sound produced by the string alone in a violin, which can be proved by holding a violin string in a vise and stretching it with the hand, drawing the bow. It is the vibrating sounding board that gives volume and tone.

HUMAN DECADENCE.

By H. D. CHAMPLIN, A.B., M.D., Cleveland, Ohio.

THERE is not one person in ten who thinks of, or seems to care for, his health until he loses it.

The most absurd excuse for neglect of duty to one's self is that he cannot always be looking after his health, in other words, he has not the moral power to abstain from excesses that weaken the body and shorten life as surely as night follows day.

The old Roman idea of manliness was a sound mind in a sound body. Physiologists recognize the existence of two sources of strength in the constitution; one is called the force in use and the other the reserved force, and the conservation of these forces is the desired end to be attained. The great thing in regulating and benefiting human life is not to find out new things, but to make the best of old things—to live according to nature and the will of nature's God. And certainly the high pressure that the majority of the present generation are putting upon themselves, the strain of overwork, and criminal abuse of their stomachs and organs generally, show a disposition to live according to no law.

Dr. John Brown, of Edinburgh, tells the following story in one of his books: "One day on my return to the office I asked the servant if any person had called, and was told that some one had. 'Who was it?' 'Oh, it's the little gentleman that aye *rins when he walks*.'" So it is with this age and people, and one wishes they would walk more and "rin" less.

A man can walk farther and longer than he can run, and it is poor saving to get out of breath.

The man of seventy, well preserved mentally and physically, with ten children and as many grandchildren, is of more value to the community than twenty men who die at thirty, and, it is to be hoped, unmarried. More than half the bad effects of overwork might be prevented by a little plain knowledge, attention, and judicious use of good sense on the part of the family physician. Educate your patients in regard to themselves; make them acquainted with the fact that they have a stomach, and define its location (few, very few, seem to have a correct idea as to where it is). Explain the fact that it is the laboratory in which the most wonderful chemical processes constantly go on, that whatever goes into it is at once acted upon chemically, and the nutritious and wholesome portions go to build up and strengthen the system. Improper food, improper hours of eating, liquor drinking and tobacco using, put an extra amount of work and fatigue upon it in the effort to sustain life.

What a man habitually eats and drinks has much to do with the condition of mind and body.

Matthew Prior has these stout old lines:

"The plainest man alive may tell ye
The seat of empire is the belly:
From thence are sent out those supplies
Which make us either stout or wise.
The strength of every other member
Is founded on your stomach timber;
The qualms or raptures of your blood
Rise in proportion to your food.
Your stomach makes your fabric roll
Just as the bias rules the bowl.
That great Achilles *might* employ
The strength designed to ruin Troy,
He dined on lion's marrow, spread
On toasts of ammunition bread;
But by his mother sent away
Among the Thracian girls to play,
Effeminate he sat and quiet,
Strange product of a cheese cake diet.
Observe the various operations
Of food and drink in several nations.
Was ever Tartar fierce or cruel
Upon the strength of water gruel?
But who shall stand his rage and force
If first he rides, then eats his horse?
Salads and eggs and lighter fare
Turn the Italian spark's guitar,
And, if I take Dan Congreve right,
Pudding and beef make Britons fight."

—*The Medical Era.*

AIR TREATMENT AND WATER TREATMENT.

HYDROTHERAPEUTICS comes in for its share of recognition or disdain, like every other special method of therapeutics, according to the standpoint of its critics. Differences of opinion arise not from knowledge, but from ignorance. Orthodoxy and heterodoxy exist even in medicine, and the laws governing them are just what they always have been. Air treatment and water treatment fare no worse than other special measures. The humorist whose acquaintance numbers many physicians seldom finds his occupation gone, or even going, and learns by frequent experience that there is a time to laugh. Specialists have a way now and then of viewing the professional world at large from a height, and criticising the scenery with dispassionate coolness most beautiful to behold. According to the kaleidoscopic standpoint, the surgeons have all gone mad, the gynecologists ought to be murdered, neurologists are quite beyond belief, a plaster jacket is the deadliest of infernal machines, and there is nothing in electricity, systematized mechanical exercises savor strongly of quackery—and more indefinitely of this same judicial pattern. A literal interpretation of the doleful presentment almost prompts the retentive listener to agree henceforth and forever with the cheerless Oxford student that nothing is worth while and it does not much matter. The humorist laughs last and best, rejoicing that truth is not a monopoly, but exists at the top—where there is always room for more of it—at the bottom, and all the way up and down the medical profession.

The laity also has its prejudices. Systematized hygiene in an appropriate locality, as a means of cure, does not appeal to every sufferer. This age affords such rare opportunities for æsthetic invalidism that getting well off in a corner, so to speak, seems to the professional invalid a waste of valuable material.

The average patient finds taking something far more attractive than working for his health. It is such a bore to do things even when a prophet does command it. Yet a life of rule and discipline in a new environment, early rising and early going to bed, regular and sufficient open air exercise under a watchful and ever-present eye, away from the interruptions, duties, cares, and habits of home surroundings, is the kind of existence best suited to a large class of those who suffer from various degrees of invalidism. There are many chronic diseases differing in kind, but having this in common, that, either from the constitutional state or from the nature of the malady, drugs alone are little better than useless. For these, bold yet skillful treatment of an entirely different kind will avail. To break up the tiresome old vault of heaven into new forms is the first essential. The patient must go into another business—that of getting well. He must live for a time almost exclusively for self, that years of self-forgetfulness may be the reward of this personal sacrifice. A mountain region with its dry, bracing air and pure water, to say nothing of restful vistas for the eye, presents the most favorable external conditions to bring about this end. The chronic dyspeptic is a good example of a class that not all the skill of the general practitioner can materially aid with the ordinary means at his command. These are cases for the specialist in hydrotherapeutics—a physician who undertakes to treat a certain class of patients in a way that the general practitioner knows to be best, but has not himself the means of carrying out. This is the hydrotherapeutist's chief province, and, if honestly held to, is a very useful one. The chronic dyspeptic complains that he cannot eat; a tonic in this instance is but a spur to a lame horse. He cannot sleep; opiates but mask the mischief. He is told what he needs—a complete change of life and for a sufficient length of time, fresh air, regular dieting, and a system of baths, which, by acting on the skin, will relieve the organs of digestion, and, by acting on the nerves, will give those same organs a good start for a better running. A break-down from years of overstrain is not an affair of trying something for a week or two, whether that something is special treatment at a sanitarium or anything special at home. Time, the great restorer, is a factor of importance. The man about town, with a good frame to start with, may get the better of his troubles and keep himself in trim by a month's asceticism in the course of each year. There is another sort of nervous dyspeptic who is the product of work, worry, and waste. It is not unreasonable to ask for two or three months to restore this blighted being. Where is the error first, in the nerves or in the digestive organs? As the student answered that celebrated question: "Does the sun go round the earth, or the earth go round the sun?" the facts of the case reply: "Sometimes the one, and sometimes the other." Frequently nervous symptoms disappear as the digestion improves. But when the earth goes round the sun, so to speak, the process is slow and scarcely to be noted. It is not that the wheels are clogged, but that they never ran true.

The *Practitioner* for July, 1888, contains a paper on hydrotherapeutics and its place in medical science. The authors state quite frankly that the success of water applications depends mainly, not on the ingredients of the waters drank or bathed in, not on the temperature of the baths, their time of application, or the length of cure, but upon the precision with which the treatment is conducted, the skill with which it is adapted to the characteristics of the patient, and the watchfulness with which complications are foreseen, met, and averted. A discriminating medical man can accomplish more with an inert water than the routinist can with a most potent and appropriate spring. Baths, packs, fomentations, etc., must be mixed as the artist mixed his colors, "With brains, sir!" Imagine that our friend, the nineteenth century dyspeptic, arrives at an institution where this excellent practice prevails—weary, jaded, without appetite, sleepless, and not too happy in the matter of temper. In the morning he is introduced to the sheet or towel pack, then soused in a cold or tepid bath, according to the season or his own reactive power, this last point being of great importance and one that requires the nicest discrimination. A walk of some ten minutes or so afterward, enough for reaction but not for fatigue, finds him the surprised possessor of a good appetite for breakfast: if not to-day, then shortly. The Turkish bath or its modified form, the lamp bath, is a veritable skin-compeller, making the outside of us do a little hard work for an overburdened interior. Cold or tepid sitz baths and divers kinds of spinal rubbings—especially with mustard, an agent of far greater value than its simplicity suggests—are some of the chief forms of water application relied upon in ordinary cases. Air, exercise, rest, and recreation also play an important part. That they are not enough in themselves is proved by the experience of patients who have tried them alone, and afterward in conjunction with special treatment.

Though chronic diseases—digestive and nervous disorders, skin troubles, the syphilitic taint, etc.—are those most benefited by the hygienic measures included in the term hydrotherapeutics, simple water applications are of much service in acute cases, such as fevers, pneumonia, and peritonitis. Take, for instance, that compound of flannel and water, the fomentation, so useful in bronchitis or pneumonia. It must be properly applied or it is only a source of added worry. A thick pad of flannel carefully sewed together—not loose folded flannel—wrung out dry from hot water at a temperature just bearable, is applied to the chest and a blanket wrapped round, all being done with the greatest speed to avoid exposure, and the application renewed every ten minutes. After an hour's application, the surface of the skin is rubbed with a cold or tepid towel, and then with dry flannel. The fomentation as a counter-irritant is quite as effective as a mustard plaster or a turpentine stupe, never frays the skin, may be repeated as often as required, and is soothing and sleep-producing. This same fomentation over the abdomen combats insomnia successfully. A cold water compress at night, well covered with flannel, has again and again dispersed what promised to be sore throat; and hot and cold water in headache are remedies almost too trite to mention.

In what waters shall we wash and be clean? In the springs at home whenever possible, and abroad whenever necessary. The iodine and bromine waters of Kreuznach and Soden are adapted to chronic disease of the scrofulous type, while the sulphur waters found at Eaux-Bonnes, Bagneres de Bigorre, and Luchon exercise their special virtues in recurring catarrhal disorders of the pulmonary or digestive tract, and are of marked benefit when herpetic affections exist. The waters of Mont Dore, Bourboule, and Royat are of service in virtue of the arsenic they contain, and still

more owing to their mode of application. For neurasthenics and dyspeptics, the dry, bracing air, pure water, and easily obtained hill exercise of such places as Tunbridge Wells, Buxton, and Malvern cannot be excelled if their natural advantages are supplemented by a course of rational hydrotherapeutics. The Delaware Water Gap region rivals the English resorts; and the sanitarium at Experiment Mills, Pennsylvania, three miles back of the Gap proper, is said to unite all the requirements of situation, beauty of scenery, and sensible management. More accessible than Bagneres de Bigorre and of the same class are the Rock Alum and Rockbridge Alum Springs. The water of Eaux-Bonnes is somewhat like that of the Greenbrier White Springs of West Virginia. It is almost always possible to find on this side of the Atlantic springs and localities as useful as European resorts. But the extra-medicinal factors, the mechanics of the situation, are too often in a crude state. This is not always so. As Dr. Coan says, when we come to have more of such admirably appointed establishments as the sanitarium at Dansville, New York, foreign travelers will frequent our waters as we do theirs at the present time. For the overstrained inhabitants of large cities, jarring their brains and spinal cords by the continual treading of stone and brick on an almost uninterrupted level, wearied by incessant noise and the absence of any wide range for the eye, with nothing in particular for the arms to do at any time, and the consequent lessened chest expansion, air treatment and water treatment hold a unique place as restorative measures. Such a hygienic course as has been indicated is entitled to a recognized place in the list of scientific methods.—*N. Y. Medical Journal.*

[AMER. CHEMICAL JOURNAL.]

(Contributions from the Chemical Laboratory of Vanderbilt University.)

I.—SOME MODIFICATIONS OF THE METHODS OF ORGANIC ANALYSIS BY COMBUSTION.

By WM. L. DUDLEY.

THE investigations recorded here were undertaken with the hope that the method of ultimate organic analysis by combustion might be so modified as to be more rapid and none the less accurate.

The time required in preparation for the combustion by ordinary methods is much greater than that for the operation itself; it being consumed in drying and mixing materials, filling and heating up the tube, and in case several combustions are to be made at once, the time required in cooling the tube is very considerable. Then again the liability of loss by breaking the tube in heating and cooling is of no little importance.

The method of burning the substance with a current of air or oxygen in a glass combustion tube containing copper oxide is well known. It is stated, however, without satisfactory reason,* that the discrepancy in the hydrogen determinations is as great in this method as in that where the substance and copper oxide are mixed, even though in the former the copper oxide is kept hot and the substance introduced in a boat. Kopfer† has described a method in which he employs platinum-black mixed with freshly ignited asbestos, instead of copper oxide; and to prevent the gases from passing through the tube without decomposition, he interposes three plugs of asbestos wound with fine platinum wire. The method is said to give very accurate results under careful management.

The platinum combustion tube which is being so generally used in carbon determinations in iron has, as far as I am aware, never before been used in organic analysis, and the method that I shall describe here can be used with a glass as well as a platinum tube, though the description will be confined to the latter, as it is much preferred. Fig. 1 shows a section of the platinum tube which is used in this laboratory, the main body of which is 48·5 cm. long and 1·5 cm. in diameter. The tail, D, is 13 cm. long and 0·5 cm. in diameter. The tube is filled from one-third to one-half full with manganese oxide in a coarse granulated condition, several lumps too large to pass through the tail, D, being put in first. The manganese oxide is prepared as follows:

FIG. 1.

Manganous carbonate is decomposed with moderately dilute nitric acid in the cold, and evaporated to dryness. The residue is heated to redness over a blast lamp until all of the nitrate is decomposed. The mass, which is for the most part the oxide Mn_2O_3, is cooled and easily granulated to any degree of fineness. No channel is left in the tube, as the manganese oxide should be coarse enough to allow the products of combustion to pass with sufficient freedom. If a glass tube be used, a slight channel should be left. The substance is introduced in a porcelain or platinum boat,‡ B, and followed by a roll of platinum gauze, C, 3·5 cm. long, which has a loop in front so that it can be easily withdrawn. At E a gas-tight brass coupling is inserted; this carries a tube 0·5 cm. in diameter, to which is connected the apparatus furnishing either air or oxygen as desired.

Instead of the size of the tube being reduced to 0·5 cm. in the tail, D, Fig. 1, the design shown in Fig. 2 is

FIG. 2.

proposed to facilitate the passage of the water into the calcium chloride tube. The tube, B, is only slightly smaller than the main body, and the end is closed with a stopper carrying the stem of the calcium chloride tube. At A is placed a platinum basket to retain the manganese oxide.

* Lieben, Ann. Chem. (Liebig), 187, 142.

† J. Chem. Soc., 29, 660.

‡ A porcelain boat is preferred in most cases, as the substance burns more uniformly in it than in a platinum boat.

The whole plan of the apparatus is shown in Fig. 3. Before introducing the substance, and connecting the calcium chloride tube and potash bulb, the portion of the tube containing the manganese oxide is heated to full redness and a rapid current of dry and pure air is passed through. The burners are shut off, except the last two or three, which are sufficient to keep about two inches of the tube red hot. The current of air is then stopped and the calcium chloride tube and potash bulbs are attached, and finally the substance is introduced in a platinum or porcelain boat (by removing the coupling at the posterior end), followed by the roll of platinum gauze. A slow current of air is then turned on, it having been purified by passing through the apparatus shown at A, Fig. 3, containing, 1st, a strong

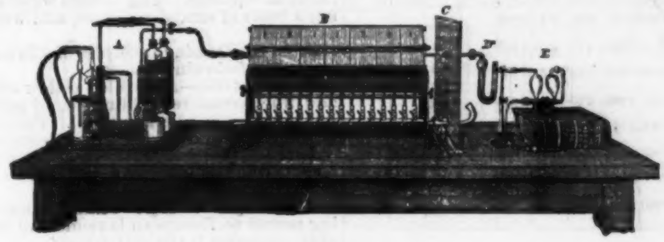


FIG. 3.

solution of caustic potash; 2d, pumice and sulphuric acid; and, 3d, solid caustic potash. Two burners under the portion of the tube containing the roll of platinum gauze are now lighted, and the substance is gradually approached by lighting the burners under the manganese oxide. The red hot platinum gauze will decompose any condensable gases which may diffuse back, if the combustion should proceed a little too rapidly, and prevent a deposit in the posterior portion of the tube outside of the furnace. An asbestos shield, C, Fig. 3, protects the calcium chloride tube and potash bulbs from the heat of the furnace.

I prefer to use a Geissler potash bulb with tube for solid potash attached, in which case the air or oxygen may be forced in at the rate of two or three bubbles a second. It is also desirable to use a slight exhaust as well as pressure.

When all the burners have been lighted, the air is replaced by a current of oxygen, which is continued for about fifteen minutes, when the combustion will have been completed. The burners are then all turned off excepting the three at the end under the manganese oxide, and the bulbs are disconnected and set aside to cool. In a few minutes the platinum gauze may best be removed with a bent wire, and if a second set of bulbs be ready, another combustion may proceed at once. In this way a combustion may be made easily every hour, the actual time consumed in burning the substance being from thirty to forty minutes.

The manganese oxide is regenerated by the oxygen which is passed in during each combustion; it is never reduced below MnO, and therefore can do the platinum tube no damage. We have a platinum tube in which over fifty combustions were made during two months without removing the manganese oxide, and on examination afterward, the inside of the tube was found to be as clean and sound as ever.

As for the accuracy of the method, I will simply give five results of the analyses of sugar made by Mr. L. M. Donaldson under my direction.

No.	Carbon.	Hydrogen.
1.	42·00	6·62
2.	42·20	6·52
3.	42·02	6·56
4.	42·08	6·55
5.	42·07	6·24
Mean,	42·07	6·49
Theory,	42·10	6·44
Error,	—·03	+·05

I also give five results obtained by him by the same method, using a glass tube instead of platinum. They are as follows:

No.	Carbon.	Hydrogen.
1.	41·90	6·43
2.	41·92	6·37
3.	42·05	6·41
4.	42·24	6·36
5.	41·99	6·37
Mean,	42·02	6·39
Theory	42·10	6·44
Error,	—·08	—·05

The method of carrying on the combustion of liquids of high boiling point is similar to that for solids. The required amount of liquid is placed in the boat and the combustion proceeded with as before, except in most cases it is best to approach the substance with the heat a trifle more slowly. For convenience in weighing and handling such liquids, I have used the arrangement shown in Fig. 4. It consists simply of a

FIG. 4.

thin glass bottle with a stopper, B, through which passes a tube, C, reaching to the bottom. A is a rubber bulb attached to the end of the tube, forming an ordinary liquid dropper. The bottle containing the liquid is weighed, and after the requisite amount of the substance for combustion has been transferred to the boat by means of the dropper, the whole is weighed again.

In the case of very volatile liquids, the following method is employed: The volatile liquid is drawn into the bulb, A, about 3·5 cm. in diameter, shown in Fig. 5, and the whole weighed. The bulb is then connected by the limb, D, to the combustion tube, and by the other to the purifying apparatus, A, Fig. 3. The combustion tube is filled three-fourths full of manganese oxide and heated to redness before the bulb containing the liquid is attached; the calcium chloride and potash bulbs are also previously connected. A slow current of nitrogen is then passed through the apparatus to serve simply as a carrier of the vapor of the substance, and to avoid danger of explosion, which would exist if oxygen or air was employed for the same purpose. A few inches below the bulb, A, Fig. 5, is placed an iron plate, B, of sufficient size to evenly distribute the heat, which is furnished by the lamp, C, through the bulb and connecting tubes, so as to prevent the condensation of the liquid *en route* to the combustion tube. The temperature of the plate should be so regulated as to rapidly evaporate the liquid in the bulb, but without boiling it. After all of the liquid has left the bulb and passed into the combustion tube, the current of nitrogen is cut off, and air or oxygen is turned on. The latter is always preferred. The use of nitrogen in

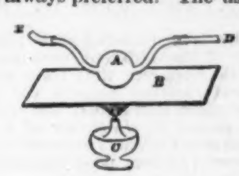


FIG. 5.

no way interferes with the combustion of the substance, and the absorption of it by the potash bulb is not materially appreciable in the results. The nitrogen may be prepared sufficiently pure by passing air over red hot copper in a porcelain tube, and then through caustic potash to a gas holder.

As mentioned before, a glass combustion tube may be used, in which case, of course, it should be straight, with stoppers fitting at each end. When glass is employed, a little more time is necessarily required, owing to the caution which must be used in heating and cooling.

I do not deem it necessary to speak of the advantages of the platinum over the glass tube, but I will simply say that its cost is soon paid for in time and labor saved.

I prefer manganese oxide to copper oxide, even if the old method of combustion is employed, because it is much lighter, quite as effective, and forms a mass more easily permeable by the gases.

ANALYSIS OF SOME SOUTHERN FRUITS WITH REFERENCE TO THEIR FOOD VALUES.

By CHARLES L. PARSONS.

KONIG, in his well known work, "Nahrungs- und Genussmittel," gives a summary of all published analyses of fruits,* their nutritive ratio and food units. This summary contains the analyses of a large number of fruits, but singularly enough but one analysis of oranges is given, and that was made previously to the investigation by Buignet, in which the existence of cane sugar in acid fruits was conclusively proved.†

Of late years oranges have become so important both as a food and a luxury, and have become so great a source of wealth to some of our Southern States, especially Florida, that I decided to make food analyses of the prominent varieties grown in that State. I have also made analyses of pomegranates and persimmons, which, although seldom seen in the Northern markets, still form no inconsiderable part of the fruits of the South.

For my purpose I obtained direct from a friend in Oviedo, Florida, a box containing eight different varieties of oranges fresh from the grove. The oranges were carefully labeled, and each wrapped in tissue paper. The pomegranates and persimmons were obtained from Hawkinsville, Georgia. I commenced work on the fruits as soon as they arrived. For the analyses a number of oranges were taken of each variety; total acids and water determined in an average sample of the fresh fruit, and the remainder of the pulp dried at about 95° C. Pomegranates and persimmons were treated in the same way, with the exception that the pulp of the persimmons was separated from the seed by means of a large-meshed sieve, previous to drying.

In the following tables I have given a comparison of the dry substance of the fruits analyzed with the dry substance of bread, cocoanut, and banana, giving their nutritive ratio and number of food units. I selected the Navel as a type of the Florida oranges in this comparison, and the Guy Pope, a Messina orange, sold last season in large quantities from New York City, as a type of the Mediterranean orange, of which more than two million dollars' worth are annually imported.

* Konig, Nahrungs- und Genussmittel, 2d edition, Bd. II, S. 491-497.

† Ann. de Chim. et de Phys. [3d series], 61, 233.

The following results are averages of my analyses :

	H_2O.	Crude protein.	Free acids.	Glucose sugar.	Cane sugar.	Ether ext.	Crude fiber.	Ash.	Albuminoid nitrogen.	Nitrogen free extract.
Sweet pomegranates........	78·37	1·33	0·366	11·61	1·04	1·24	2·63	0·761	0·177	15·77
Sour pomegranates	75·41	1·60	1·85	10·40	0·96	2·05	2·83	0·544	0·203	17·57
Persimmons	66·12	0·827	0·000	18·54	1·03	0·701	1·78	0·861		29·711
Florida orange, Bitter Sweet. ...	86·86	0·815	0·417	5·71	0·84	0·248				
Florida orange, Tangerine......	83·56	0·792	0·477	6·00	3·41	0·256				
Florida orange, Mandarin.. ..	79·95	0·834	0·855	4·77	8·07	0·146				
Florida orange, Bloods..........	85·57	0·700	0·670	5·70	3·94	0·100				
Florida orange, Navels..........	83·70	1·12	0·662	6·03	4·66	0·294				
Florida orange, Russets........	83·18	0·905	0·817	7·29	4·51					
Florida orange, common Florida	86·58	0·802	0·756	4·60	4·38	0·076				
Florida orange, Florida sour....	86·76	1·03	2·55	3·86	0·97	0·125				
Messina orange, Guy Pope.......	86·22	0·980	1·18	5·95	1·89	0·166				

	Ntg=Protein.	Fat.	Nitrogen—free Extract= N. Ntg.	Nutritive Ratio Ntg : N. Ntg + (1¾ × fat) :: 1:—	Food Units in 1 kilo : Ntg : fat : N. Ntg:: 5 : 3 : L	Nutritive Ratio = Ntg : N. Ntg + (fat × 175) :: 1 :—
Bread..........................	10·94	87·97	0·71	8·7	1446·2	
Sweet pomegranates,.....	6·12	72·52	5·70	13·5	1202·2	
Sour pomegranates...	6·50	71·44	8·34	13·4	1289·6	
Persimmons	2·44	90·63	2·07	38·6	1090 4	
Banana......	6·94	85·72	2·33	12·0	1274·1	
Solid portion cocoanut...	10·31	15·10	67·33	12·9	2686·4	
Mandarin orange...........	4·15	85·88	0·73	21·0	1088·2	
Navel orange................	6·87	80·85	1·44	12·1	1195·2	
Guy Pope orange...........	5·78	71·11	1·22	12·7	1096·7	

To any one who is acquainted with the flavor and general edibility of the different varieties of Florida oranges, it will be apparent that these analyses indicate that the best varieties contain the highest percentages of cane sugar, and that if the analyzed varieties were to be placed in the order of their superior flavor, and in the order of their contents of cane sugar, the two series would be very nearly identical.—*American Chemical Journal.*

NOTES ON ESSENTIAL OILS.*

Wintergreen Oil.—Mention is made that recently samples of wintergreen oil from Java have been received, and some doubt is expressed as to its botanical origin. [It may be mentioned that seventeen years ago Dr. Vrij stated in this *Journal* (vol. ii., p. 503) that probably wintergreen oil could be distilled profitably in Java from the leaves of *Gaultheria punctata.*]

Ylang-Ylang Oil.—According to information received from Manila, the differences in quality of the numerous varieties of this oil met with in commerce depend principally upon the method of preparation and the selection of blossoms, as these possess the finest aroma when freshly picked. In the distillation the first, most volatile, portion of the oil has an incomparably fine perfume, while that distilling over afterward gradually manifests a stale odor; the finest oil is therefore sent out by those firms that distill only the first portion. In practice if 100 kilos of fresh flowers would yield 1,200 grammes of oil, the finest aroma would be concentrated in the first 600 grammes that passed over.

Dilem Leaves Oil.—From Java a sample of "dilem leaves" has been received, possessing a very fine perfume and yielding about one per cent. of an ethereal oil that in odor is said to resemble patchouli oil, but to smell essentially fresher, finer, and less musty. It is a yellowish green, moderately thick liquid, has a specific gravity of 0·960 and boils between 250° and 300° C. It is considered that if the cost of producing this oil should prove to be not too great, it might take an important place in perfumery, and steps are therefore being taken to determine the origin of the leaves and obtain a supply.

Massoy Bark Oil.—A large supply of massoy bark having been secured through the agency of the German New Guinea Company, an appeal is made to the patriotism of German perfumers and soap makers to find an application for the first product of this kind from a German colony. The oil is described as having an agreeable aromatic odor resembling cloves and nutmeg, and as being suitable as a perfume for cheap toilet soaps. The plant from which the bark is derived was discovered by D'Albertis in south New Guinea and named by Beccari *Massoia aromatica.* Gmelin, who attributes the bark to *Cinnamomum Kiamis,* Nees, gives in his "Handbuch" (iv. 356) the constituents of the oil as follows : (1) an almost colorless thin light oil, with an odor of sassafras ; (2) a thick, heavy, less volatile oil, with a weaker odor, but tasting strongly like sassafras ; and (3) massoy camphor, a white powder, heavier than water, less soft to the touch than fatty substances, odorless and almost tasteless, allied to laurin and caryophyllin and soluble in hot alcohol and in ether. In preliminary experiments Messrs. Schimmel have obtained from the bark about 7 per cent. of an oil having a specific gravity of 1·04, boiling between 200° and 300° C., and containing about 75 per cent. of eugenol. The portion of the oil insoluble in soda liquor boiled between 210° and 245° C., and among other bodies contained safrol.

Matsu Oil.—The Japanese oil mentioned under this name in a former report, and supposed to have been a distillate from a birch or beech tar, has now been ascertained to have been derived from a tar of either *Pinus massoniana* or *P. densiflora,* both of which trees pass under the name "matsu" in Japan. The former is said to show great similarity to *Pinus austriaca,* and the latter to *P. sylvestris.*

Citronelle Fruit Oil.—A large consignment of the small round berries of the size of a pea, designated "citronelle fruit," has been received from Java, and has yielded about 3½ per cent. of essential oil. This oil resembles verbena oil, and is usually powerful and rich ; its specific gravity is 0·980 and it boils from 180° to 240° C. It contains a terpene and citral (see under eucalyptus oil). In the Indies it is known under the name "minjak sereh," and is credited with being a panacea.

East Indian Oils.—Messrs. Schimmel also report upon fifteen samples of essential oil received from India, only one of which was found to be a pure distillate. This was described as "*lemon oil,*" and had a fine lemon and melissa odor, essentially finer than that of citronelle oil, and at a moderate price would probably prove acceptable. The others were all mixtures having a basis of sandal-wood oil, and were all condemned as useless.

From St. Domingo samples of oils have been received under the following names :

Bergamot Oil.—A distilled yellow oil with a powerful and fine aroma, resembling oil of petit grain in odor, but not recalling bergamot oil. Probably the distillate of the leaves and unripe fruit of some species of *Citrus.*

Lavender Oil.—A water-clear essential oil, quite different from the European varieties of lavender oil, and rather recalling spike oil in odor.

Rosemary Oil.—A powerfully aromatic oil, approaching nearer to European lavender oil in odor, and probably utilizable if the cost allows.

Bay or Mountain Laurel Oil.—An essential oil with an odor like that of laurel oil.—*Pharmaceutical Journal.*

* From Messrs. Schimmel's report.

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TABLE OF CONTENTS.